PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

TWENTY-FIRST MEETING,

HELD AT

DUBUQUE, IOWA.

AUGUST, 1872.

CAMBRIDGE:
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1873.

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EDITED BY

JOSEPH LOVERING,

Permanent Secretary.

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AT

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J. LAWRENCE SMITH, *President.*
ALEXANDER WINCHELL, *Vice-President.*
JOSEPH LOVERING, *Permanent Secretary.*
E. S. MORSE, *General Secretary.*
W. S. VAUX, *Treasurer.*

STANDING COMMITTEE.

EX-OFFICIO.

J. LAWRENCE SMITH,
ALEXANDER WINCHELL,
JOSEPH LOVERING,
E. S. MORSE,
ASA GRAY,
G. F. BARKER,
F. W. PUTNAM,
W. S. VAUX.

AS CHAIRMEN OF THE SECTIONAL COMMITTEES.

J. D. WARNER,
J. W. FOSTER.

FROM THE ASSOCIATION AT LARGE.

E. J. COX,
C. C. GILMAN,
I. A. LAPHAM,
G. C. SWALLOW,
C. A. WHITE,
H. T. WOODMAN.

LOCAL COMMITTEE.

H. T. WOODMAN, *Chairman.*
Dr. C. A. WHITE, *1st Vice-Chairman.*
Dr. ASA HORR, *2d Vice-Chairman.*
SAMUEL CALVIN, *Local Secretary.*
E. D. COOK, *Assistant Secretary.*
R. A. BABBAGE, *Treasurer.*

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S. P. Adams,
J. E. Ainsworth,
W. P. Allen,
W. B. Allison,
N. C. Amsden,
W. Andrew,
H. B. Baker,
W. Barnard,
J. F. Bates,
C. Baylies,
W. H. Beach,
John Bell,
C. H. Booth,
Dr. Belden,
C. Bittman,
R. Bonson,
W. L. Bradley,
Maurice Brown,
O. A. Brownson, Jr.,
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H. Brinkman,
George W. Burton,
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W. C. Chamberlain,
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J. Christman,
Charles Clarke,
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H. B. Glover,
William Graham,
George Gray,
J. K. Graves,
J. M. Griffith,
Dr. E. A. Guilbert,
Dr. S. H. Guilbert,
M. D. Goble,
M. M. Ham,
H. S. Hetherington,
R. S. Harris,
W. E. Harriman,
William M. Hamlin,
Julius W. Haas,
John Hodgdon,
H. P. Ward,
S. S. Wemott,
V. J. Williams,
J. D. Bush,
J. T. Hancock,
A. Heeb,
D. B. Henderson,
Dr. R. L. Hill,
J. N. Hill,
Jerry Howard,
H. Hubert,
J. Herod,
Thomas Hardie,
F. Hinds,
A. F. Jaeger,
Jesse T. Jarret,
George W. Jones,
W. A. Judd,
Otto Junkerman,
James Johnston,
T. M. Irish,
Charles Kretschmer,
A. Kaiser,
J. W. Knight,
Charles Keller,
James Kelly,
A. W. Kemler,
M. Kingman,
H. M. Kingman,
E. Klingenberg,
Peter Kiene,
Kirkendall,
C. C. Lieben,
M. J. La Nicca,
J. H. Lull,
Ed. Langworthy,
Solon Langworthy,
W. P. Large,
James Levi,
D. E. Lyon,
A. B. Lewis,
D. S. Wilson,
George D. Wood,
W. W Woodworth,
R. E. Graves,
L. W. McMaster,
A. McCann,
A. Y. McDonald,
D. A. McKinlay,
H T. McNulty,
B. W. McClure,
John Maclay,
D. A. Mahony,
T. Mason,
John Mehlhop,
J. Merriam,
William Mills,
George W. Mitchel,
E. H. Moore,
M. H. Moore,
J. L. McCreery,
R. Morrill,
D. D. Myers,
Thomas M. Monroe,
J. Michel,
Fred O'Donnell,
John O'Neil,
W. H. Peabody,
A. Palmer,
J. W. Parker,
A. Peaslee,
A. Pettibone,
E. Pickenbrock,
B. B. Provost,
B. A. Powell,
W. W. Pyne,
Wm. Hyde Clark,
Jacob Rich,
L. D. Randall,
W. Rebman,
G. N. Raymond,
C. H. Remington,
William Vandever,
C. Wullweber,
Alexander Young,
R. A. Lull,
J. A. Rhomberg,
J. V. Rider.
W. H. Robison,
M. S. Robison,
John Robison,
E. D. Ruth,
F. Robinson,
S. Root,
H. Rouse,
W. H. Rumpf,
William Ryan,
W. C. Ryder,
B. B. Richards,
Platt Smith,
J. W. Smith,
E. R. Shankland,
A. W. Sears,
C. Sadler,
Dr. Joseph Sprague,
P. C. Samson,
H. W. Sanford,
F. W. H. Sheffield,
J. P. Scott,
Dr. G. W. Scott,
O. P. Shiras,
Mark Smith,
W. G. Stewart,
H. L. Stout,
A. Steward,
J. H. Thedinga,
J. H. Thompson,
John Thompson,
S. Turck,
M. M. Trumbull,
A. Tredway,
George L. Torbert,
F. Udall,
George Young,
H. Zieprecht,
M. M. Walker,
John R. Waller.

OFFICERS OF THE SECTIONS.

SECTION A.

J. D. Warner, *Chairman.* C. L. Jackson, *Secretary.*

Sectional Committee.

A. A. Breneman, G. W. Hough, Joseph Ficklin.

SECTION B.

J. W. Foster, *Chairman.* C. V. Riley, *Secretary.*

Sectional Committee.

E. B. Andrews, J. G. Morris, A. H. Worthen.

SUB-SECTION C OF SECTION A.

R. H. Ward, *Chairman.* O. S. Westcott, *Secretary.*

Sectional Committee.

H. H. Babcock, M. S. Bebb, Robert King.

SPECIAL COMMITTEES.

A. Committees continued from former Meetings.

1. *Committee to report in Relation to Uniform Standards in Weights, Measures, and Coinage.*

F. A. P. Barnard,
John F. Frazer,
Wolcott Gibbs,
B. A. Gould,
Joseph Henry,
J. E. Hilgard,
John LeConte,
H. A. Newton,
Benjamin Peirce,
W. B. Rogers,
J. L. Smith,
John Torrey.

2. *Committee to memorialize the Legislature of Missouri in favor of publishing the results of the Geological Survey of the State.*

James Hall,
Louis Agassiz,
E. T. Cox,
J. D. Dana,
E. W. Hilgard,
Charles H. Hitchcock,
T. S. Hunt,
W. C. Kerr,
J. P. Lesley,
William E. Logan,
J. S. Newberry,
Richard Owen,
J. L. Smith,
C. A. White,
J. D. Whitney,
Alexander Winchell.

3. *Committee to memorialize the Legislature of New York for a New Survey of Niagara Falls.*

F. A. P. Barnard,
Charles P. Daly,
James Hall,
William E. Logan,
G. W. Holley.

4. *Committee to report on the Best Methods of Organizing and Conducting State Geological Surveys.*

G. C. Swallow,	Alexander Winchell,
James Hall,	T. S. Hunt,
J. S. Newberry,	Benjamin Peirce.

B. New Committees.

1. *Committee to audit the Accounts of the Permanent Secretary and the Treasurer.*

H. L. Eustis,	Henry Wheatland.

2. *Committee to prepare Resolutions of Thanks.*

J. W. Foster,	Joseph Lovering,
C. S. Forshey,	E. S. Morse,
Asa Gray,	F. W. Putnam,
G. W. Hough,	G. C. Swallow,

Alexander Winchell.

3. *Committee to act with the Standing Committee in Nomination of Officers for the next Meeting.*

Section A.	Section B.
Thomas Basnett,	Henry Hartshorne,
A. A. Breneman,	P. R. Hoy,
Joseph Ficklin,	George Little,
G. W. Hough,	J. B. Perry.

4. *Committee on the Geological Survey of Iowa.*

J. W. Foster,	G. C. Swallow,
I. A. Lapham,	Alexander Winchell,

A. H. Worthen.

OFFICERS OF THE ASSOCIATION

AT

THE PORTLAND MEETING.

JOSEPH LOVERING, *President.*

A. H. WORTHEN, *Vice-President.*

F. W. PUTNAM, *Permanent Secretary.*

C. A. WHITE, *General Secretary.*

WILLIAM S. VAUX, *Treasurer.*

STANDING COMMITTEE.

JOSEPH LOVERING,
A. H. WORTHEN,
F. W. PUTNAM,
C. A. WHITE,
J. LAWRENCE SMITH,
ALEXANDER WINCHELL,
E. S. MORSE,
W. S. VAUX.

LOCAL COMMITTEE.

BENJAMIN KINGSBURY, JR., *Chairman.*

GEORGE E. B. JACKSON, *Treasurer.* | REV. CHARLES W. HAYES, *Secretary.*

John M. Adams,
William Allen, Jr.,
Samuel J. Anderson,
W. H. Anderson,
Clark H. Barker,
Sylvester B. Beckett,
James S. Bedlow,
Stephen Berry,
Rev. Egbert C. Bolles,
A. W. Bradbury,
Bion Bradbury,
Harrison B. Brown,
John B. Brown,
John Marshall Brown,
Hubbard W. Bryant,
Rev. Charles W. Buck,
Henry H. Burgess,
Dr. Charles H. Burr,

James E. Carter,
Francis Chase,
Asa W. H. Clapp,
Cyrus S. Clark,
Nathan Cleaves,
John B. Coyle,
George T. Davis,
William G. Davis,
Woodbury S. Dana,
Henry Deering,
William Deering,
Frederick N. Dow,
Josiah H. Drummond,
Edward W. Elwell,
George F. Emery,
Cyrus H. Farley,
Rev. William H. Fenn,
Francis Fessenden,
Charles S. Fobes,
Dr. Thomas A. Foster,
Franklin Fox,
H. Frank Furbish,
Charles B. Fuller,
Dr. F. H. Gerrish,
Oliver Gerrish,
Rev. William E. Gibbs,
Dr. John T. Gilman,
Charles W. Goddard,
Dr. Seth C. Gordon,
John M. Gould,
William N. Gould,
Willard W. Harris,
Charles H. Haskell,
Rev. William B. Hayden,
T. C. Hersey,
Rufus H. Hinkley,
Prof. C. H. Hitchcock,
George S. Hunt,
Charles E. Jose,
Horatio N. Jose,
Russell Lewis,
Charles F. Libby,
H. J. Libby,
Alexander W. Longfellow,
Charles A. Lord,
Prentiss Loring,
Thomas G. Loring,
Abner Lowell,
John Lynch,
Charles McCarthy, Jr.,
James T. McCobb,
Jacob McLellan,
James S. Marrett,
W. K. Mayo,
Weston F. Millikin,
William E. Morris,
John Mussey,
Charles B. Nash,
Rt. Rev. H. A. Neely,
Frank Noyes,
Eben N. Perry,
Lewis Pierce,
Luther F. Pingree,
Rev. C. B. Pitblado,
John Porteous,
Stanley T. Pullen,
William L. Putman,
Thomas B. Reed,
Charles M. Rice,
Marshall N. Rich,
Hobart W. Richardson,
Joseph S. Ricker,
Thomas A. Roberts,
Hosea L. Robinson,
Micah Sampson,
Charles J. Schumacher,
William Senter,
Rev. William H. Shailer,
George F. Shepley,
Ambrose K. Shurtleff,
Rev. Daniel F. Smith,
James H. Smith,
Lewis B. Smith,
Samuel E. Spring,
Charles A. Staples,
Augustus E. Stevens,
A. P. Stone,
Sewell C. Strout,
Francis K. Swan,
George F. Talbot,
George Thom,
William W. Thomas, Jr.,
Joseph P. Thompson,
George Trefethen,
George W. True,
Payson Tucker,
Thomas E. Twitchell,
Charles B. Varney,
Albert H. Waite,
Israel Washburn, Jr.,
Nathan Webb,
Walter Wells,
George P. Wescott,
William A. Winship,
Jacob S. Winslow,
Rufus E. Wood,
Dr. William Wood,
William E. Wood,
William R. Wood.

MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Meeting.	Date.	Place.	President.	Vice-President.	General Secretary.	Permanent Sec'y.	Treasurer.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,		Walter R. Johnson,		Jeffries Wyman.
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,		E. N. Horsford,		A. L. Elwyn.
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,*		L. R. Gibbes,*		St. J. Ravenel.*
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,		E. C. Herrick,		A. L. Elwyn.
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,		W. B. Rogers,	S. F. Baird,	A. L. Elwyn.
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,		W. B. Rogers,	S. F. Baird,	A. L. Elwyn.
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Peirce,		J. D. Dana,	S. F. Baird,	A. L. Elwyn.
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana,		J. Lawrence Smith,	Joseph Lovering,	J. L. LeConte.*
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.
10th	Aug. 20, 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.
11th	Aug. 12, 1857,	Montreal, C. E.,	J. W. Bailey,	Alexis Caswell,	John LeConte,	Joseph Lovering,	A. L. Elwyn.

* In the absence of the regular officer.

MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Meeting.	Date.	Place.	President.	Vice-President.	General Secretary.	Permanent Sec'y.	Treasurer.
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,*	John E. Holbrook,	W. M. Gillespie,	Joseph Lovering,	A. L. Elwyn.
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,	Edward Hitchcock,	William Chauvenet,	Joseph Lovering,	A. L. Elwyn.
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea,	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,	B. A. Gould,	Elias Loomis,	Joseph Lovering,	A. L. Elwyn.
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey,	Simon Newcomb,*	Joseph Lovering,	A. L. Elwyn.
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster,	O. N. Rood,	O. C. Marsh,	F. W. Putnam,*	A. L. Elwyn.
19th	Aug. 17, 1870,	Troy, N. Y.,	William Chauvenet,	T. S. Hunt, †	C. F. Hartt, ‡	Joseph Lovering,	A. L. Elwyn.
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.

* In the absence of the regular officer.

† The President elect being absent, the Vice-President took his place.

‡ Mr. F. W. Putnam was appointed to fill the place of Mr. Hartt, as he was unable to be present.

CONSTITUTION OF THE ASSOCIATION.*

OBJECTS.

THE Association shall be called THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States; to give a stronger and more general impulse and a more systematic direction to scientific research in our country; and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS.

RULE 1. Any person may become a member of the Association upon recommendation in writing by two members, nomination by the Standing Committee, and election by a majority of the members present.

OFFICERS.

RULE 2. The officers of the Association shall be a President, Vice-President, General Secretary, Permanent Secretary, and Treasurer. The President, Vice-President, General Secretary, and Treasurer shall be elected at each meeting for the following one; — the three first named officers not to be re-eligible for the next two meetings, and the Treasurer to be re-eligible as long as the Association may desire. The Permanent Secretary shall be elected at each second meeting, and also be re-eligible as long as the Association may desire.

* Adopted August 25, 1856, and ordered to go into effect at the opening of the Montreal Meeting. Amended at Burlington, August, 1867, and at Chicago, August, 1868.

MEETINGS.

RULE 3. The Association shall meet, at such intervals as it may determine, for one week, or longer; and the arrangements for it shall be intrusted to the officers and the Local Committee. The Standing Committee shall have power to determine the time and place of each meeting, and shall give due notice of it to the Association.

STANDING COMMITTEE.

RULE 4. There shall be a Standing Committee, to consist of the President, Vice-President, Secretaries, and Treasurer of the Association, the officers of the preceding year, the Permanent Chairmen of the Sectional Committees, after these shall have been organized, and six members present from the Association at large, who shall have attended any of the previous meetings, to be elected upon open nomination by ballot on the first assembling of the Association. A majority of the whole number of votes cast, to elect. The General Secretary shall be Secretary of the Standing Committee.

The duties of the Standing Committee shall be, —

1. To assign papers to the respective Sections.

2. To arrange the scientific business of the general meetings, to suggest topics, and arrange the programmes for the evening meetings.

3. To suggest to the Association the place and time of the next meeting.

4. To examine, and, if necessary, to exclude papers.

5. To suggest to the Association subjects for scientific reports and researches.

6. To appoint the Local Committee.

7. To have the general direction of publications.

8. To manage any other general business of the Association during the session, and during the interval between it and the next meeting.

9. In conjunction with four from each Section, to be elected by the Sections for the purpose, to make nominations of officers of the Association for the following meeting.

10. To nominate persons for admission to membership.

11. Before adjourning, to decide which papers, discussions, or other proceedings shall be published.

SECTIONS.

RULE 5. The Association shall be divided into two Sections, and as many sub-sections as may be necessary for the scientific business. When not otherwise ordered the sub-sections shall be as follows: SECTION A. — (1) Mathematics and Astronomy; (2) Physics and Chemistry; (3) Microscopy. SECTION B. — (1) Zoölogy and Botany; (2) Geology and Palæontology; (3) Ethnology and Archæology. The two Sections may meet as one.

SECTIONAL OFFICERS AND COMMITTEES.

RULE 6. On the first assembling of the Section, the members shall elect upon open nomination a permanent Chairman and Secretary, also three other members, to constitute, with these officers, a Sectional Committee.

The Section shall appoint, from day to day, a Chairman to preside over its meetings.

RULE 7. It shall be the duty of the Sectional Committee of each Section to arrange and direct the proceedings in their Section; to ascertain what communications are offered; to assign the order in which these communications shall appear, and the amount of time which each shall occupy.

The Sectional Committees may likewise recommend subjects for systematic investigation by members willing to undertake the researches, and to present their results at the next meeting.

The Sectional Committee may likewise recommend reports on particular topics and departments of science, to be drawn up as occasion permits, by competent persons, and presented at subsequent meetings.

REPORTS OF PROCEEDINGS.

RULE 8. Whenever practicable the proceedings shall be reported by professional reporters, or stenographers, whose reports are to be revised by the Secretaries before they appear in print.

PAPERS AND COMMUNICATIONS.

RULE 9. No paper shall be placed in the programme, unless admitted by the Sectional Committee; nor shall any be read, unless an abstract of it has been previously presented to the Secretary of the Section, who shall furnish to the Chairman the titles of papers, of which abstracts have been received.

Rule. 10. The author of any paper or communication shall be at liberty to retain his right of property therein, provided he declare such to be his wish before presenting it to the Association.

Rule 11. Copies of all communications, made either to the General Association or to the Sections, must be furnished by the authors; otherwise only the titles, or abstracts, shall appear in the published proceedings.

Rule 12. All papers, either at the general or in the sectional meetings, shall be read, as far as practicable, in the order in which they are entered upon the books of the Association; except that those which may be entered by a member of the Standing Committee of the Association shall be liable to postponement by the proper Sectional Committee.

Rule 13. If any communication be not ready at the assigned time, it shall be dropped to the bottom of the list, and shall not be entitled to take precedence of any subsequent communication.

Rule 14. No exchanges shall be made between members without authority of the respective Sectional Committees.

GENERAL AND EVENING MEETINGS.

Rule 15. The Standing Committee shall appoint any general meeting which the objects and interests of the Association may call for, and the evenings shall, as a rule, be reserved for general meetings of the Association.

These general meetings may, when convened for that purpose, give their attention to any topics of science which would otherwise come before the Sections.

It shall be a part of the business of these general meetings to receive the Address of the President of the last meeting; to hear such reports on scientific subjects as, from their general importance and interest, the Standing Committee shall select; also, to receive from the Chairmen of the Sections abstracts of the proceedings of their respective Sections; and to listen to communications and lectures explanatory of new and important discoveries and researches in science, and new inventions and processes in the arts.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

RULE 16. The Association shall be called to order by the President of the preceding meeting; and this officer having resigned the chair to the President elect, the General Secretary shall then report the number of papers relating to each department which have been registered, and the Association consider the most eligible distribution into Sections, when it shall proceed to the election of the additional members of the Standing Committee in the manner before described; the meeting shall then adjourn, and the Standing Committee, having divided the Association into Sections as directed, shall allot to each its place of meeting for the Session. The Sections shall then organize by electing their officers and their representatives in the Nominating Committee, and shall proceed to business.

PERMANENT SECRETARY.

RULE 17. It shall be the duty of the Permanent Secretary to notify members who are in arrears, to provide the necessary stationery and suitable books for the list of members and titles of papers, minutes of the general and sectional meetings, and for other purposes indicated in the rules, and to execute such other duties as may be directed by the Standing Committee or by the Association.

The Permanent Secretary shall make a report annually to the Standing Committee, at its first meeting, to be laid before the Association, of the business of which he has had charge since its last meeting.

All members are particularly desired to forward to the Permanent Secretary, so as to be received before the day appointed for the Association to convene, complete titles of all the papers which they expect to present during its meeting, with an estimate of the time required for reading each, and such abstracts of their contents as may give a general idea of their nature.

Whenever the Permanent Secretary notices any error of fact or unnecessary repetition, or any other important defect in the papers communicated for publication in the "Proceedings" of the Association, he is authorized to commit the same to the author, or to the proper sub-committee of the Standing Committee for correction.

LOCAL COMMITTEE.

RULE 18. The Local Committee shall be appointed from among members residing at, or near, the place of meeting for the ensuing year; and it shall be the duty of the Local Committee, assisted by the officers, to make arrangements and the necessary announcements for the meeting.

The Secretary of the Local Committee shall issue a circular in regard to the time and place of meetings, and other particulars, at least one month before each meeting.

SUBSCRIPTIONS.

RULE 19. The amount of the subscription, at each meeting, of each member of the Association, shall be two dollars, and one dollar in addition shall entitle him to a copy of the "Proceedings" of the annual meeting. These subscriptions shall be received by the Permanent Secretary, who shall pay them over, after the meeting, to the Treasurer.

The admission fee of new members shall be five dollars, in addition to the annual subscription; and no person shall be considered a member of the Association until this admission fee and the subscription for the meeting at which he is elected have been paid.

RULE 20. The names of all persons two years in arrears for annual dues shall be erased from the list of members; provided that two notices of indebtedness, at an interval of at least three months, shall have been previously given.

ACCOUNTS.

RULE 21. The accounts of the Association shall be audited, annually, by auditors appointed at each meeting.

ALTERATIONS OF THE CONSTITUTION.

RULE 22. No article of this Constitution shall be altered, or amended, or set aside, without the concurrence of three-fourths of the members present, and unless notice of the proposed change shall have been given at the preceding annual meeting.

RESOLUTIONS

OF A PERMANENT AND PROSPECTIVE CHARACTER, ADOPTED AUGUST 19, 1857.

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1. No appointment may be made in behalf of the Association, and no invitation given or accepted, except by vote of the Association or its Standing Committee.

2. The General Secretary shall transmit to the Permanent Secretary for the files, within two weeks after the adjournment of every meeting, a record of the proceedings of the Association and the votes of the Standing Committee. He shall also, daily, during the meetings, provide the Chairmen of the two Sectional Committees with lists of the papers assigned to their Sections by the Standing Committee.

3. All printing for the Association shall be superintended by the Permanent Secretary, who is authorized to employ a clerk for that especial purpose.

4. The Permanent Secretary is authorized to put the "Proceedings" of the meeting to press one month after the adjournment of the Association. Papers which have not been received at that time may be published only by title. No notice of articles not approved shall be taken in the published "Proceedings."

5. The Permanent Chairmen of the Sections are to be considered their organs of communication with the Standing Committee.

6. It shall be the duty of the Secretaries of the two Sections to receive copies of the papers read in their Sections, all sub-sections included, and to furnish them to the Permanent Secretary at the close of the meeting.

7. The Sectional Committees shall meet not later than nine A.M. daily, during the meetings of the Association, to arrange the programmes of their respective Sections, including all sub-sections,

for the following day. No paper shall be placed upon these programmes which shall not have been assigned to the Section by the Standing Committee. The programmes are to be furnished to the Permanent Secretary not later than eleven A.M.

8. During the meetings of the Association, the Standing Committee shall meet daily, Sundays excepted, at nine A.M., and the Sections be called to order at ten A.M., unless otherwise ordered. The Standing Committee shall also meet on the evening preceding the first assembling of the Association at each annual meeting, to arrange for the business of the first day; and on this occasion three shall form a quorum.

9. Associate members may be admitted for one, two, or three years, as they shall choose at the time of admission, — to be elected in the same way as permanent members, and to pay the same dues. They shall have all the social and scientific privileges of members, without taking part in the business.

10. No member may take part in the organization and business arrangement of both the Sections.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

A.

Abbe, Cleveland, Washington, District of Columbia (16).
*Adams, C. B., Amherst, Massachusetts (1).
*Adams, Edwin F., Charlestown, Massachusetts (18).
Adams, Samuel, Jacksonville, Illinois (18).
Agassiz, Alexander E. R., Cambridge, Massachusetts (18).
Agassiz, Louis, Cambridge, Massachusetts (1).
Aiken, W. E. A., Baltimore, Maryland (12).
Ainsworth, Frank B., Plainfield, Indiana (20).
Albert, Augustus J., Baltimore, Maryland (12).
Alexander, Stephen, Princeton, New Jersey (1).
Allen, Joel A., Cambridge, Massachusetts (18).
Allen, Zachariah, Providence, Rhode Island (1).
Alvord, Benjamin, Washington, District of Columbia (17).
*Ames, M. P., Springfield, Massachusetts (1).
Andrews, Ebenezer, Chicago, Illinois (17).
Andrews, E. B., Columbus, Ohio (7).
Andrews, Joseph H., Chicago, Illinois (17).
*Appleton, Nathan, Boston, Massachusetts (1).
Atwater, Elizabeth E., Chicago, Illinois (17).
Atwater, Samuel T., Chicago, Illinois (17).
Austin, E. P., Cambridge, Massachusetts (18).
Avery, Alida C., Poughkeepsie, New York (20).

NOTE. — Names of deceased members are marked with an asterisk [*]. The figure at the end of each name refers to the meeting at which the election took place.

B.

Babcock, George, Troy, New York (19).
Babcock, Henry H., Chicago, Illinois (17).
*Bache, Alexander D., Washington, District of Columbia (1).
Bacon, John, Jr., Boston, Massachusetts (1).
*Bailey, J. W., West Point, New York (1).
Bailey, Loring W., Frederickton, New Brunswick (18).
Baird, Lyman, Chicago, Illinois (17).
Baird, S. F., Washington, District of Columbia (1).
Bannister, Henry M., Washington, District of Columbia (17).
Bardwell, F. W., Lawrence, Kansas (18).
Barker, G. F., New Haven, Connecticut (18).
Barnard, F. A. P., New York, New York (7).
Barnard, J. G., New York, New York (14).
Basnett, Thomas, Ottawa, Illinois (8).
Bassett, George W., Vandalia, Illinois (20).
Batchelder, J. H., Salem, Massachusetts (18).
Batchelder, J. M., Cambridge, Massachusetts (8).
*Beck, C. F., Philadelphia, Pennsylvania (1).
*Beck, Lewis C., New Brunswick, New Jersey (1).
*Beck, T. Romeyn, Albany, New York (1).
Bell, James D., New York, New York (20).
Bell, Samuel N., Manchester, New Hampshire (7).
Benjamin, E. B., New York, New York (19).
Bethune, Charles J. S., Port Hope, Canada (18).
Bickmore, Albert S., New York, New York (17).
Bicknall, Edwin, Cambridge, Massachusetts (18).
Bill, Charles, Springfield, Massachusetts (17).
*Binney, Amos, Boston, Massachusetts (1).
*Binney, John, Boston, Massachusetts (3).
Blake, Eli W., Providence, Rhode Island (15).
Blake, Eli W., New Haven, Connecticut (1).
*Blanding, William, Rhode Island (1).
Blatchford, Eliphalet W., Chicago, Illinois (17).
Blatchley, S. L., New Haven, Connecticut (19).
Boadle, John, Haddonfield, New Jersey (20).
Bolles, E. C., Salem, Massachusetts (17).
Bolton, H. C., New York, New York (17).
*Bomford, George, Washington, District of Columbia (1).
Bontencou, R. B., Troy, New York (19).
Bouvé, Thomas T., Boston, Massachusetts (1).
Bowditch, Henry I., Boston, Massachusetts (2).
Bowen, Chauncey W., Chicago, Illinois (17).
Bowen, James H., Chicago, Illinois (17).
Bowen, Silas T., Indianapolis, Indiana (20).
Boynton, Susan P., Lynn, Massachusetts (19).
Brackett, C. F., Brunswick, Maine (19).
Bradley, L., Jersey City, New Jersey (15).

Breneman, A. A., Agricultural College, Pennsylvania (20).
Brevoort, J. Carson, Brooklyn, New York (1).
Brewer, W. H., New Haven, Connecticut (20).
Briggs, A. D., Springfield, Massachusetts (18).
Briggs, D. H., Norton, Massachusetts (18).
Briggs, S. A., Chicago, Illinois (17).
Brigham, Charles H., Ann Arbor, Michigan (17).
Bross, William, Chicago, Illinois (7).
Brown, Robert, Jr., Cincinnati, Ohio (11).
Brown, Mrs. Robert, Jr., Cincinnati, Ohio (17).
Brush, George J., New Haven, Connecticut (11).
Bryan, Oliver N., Marshall Hall P. O., Maryland (18).
Buchanan, Robert, Cincinnati, Ohio (2).
Burbank, L. S., Lowell, Massachusetts (18).
Burden, Henry, Jr., Troy, New York (19).
Burgess, Abby L., Oxford, Ohio (20).
*Burnap, G. W., Baltimore, Maryland (12).
*Burnett, Waldo I., Boston, Massachusetts (1).
Bush, Stephen, Waterford, New York (19).
Bushee, James, Worcester, Massachusetts (9).
Butler, Thomas B., Norwalk, Connecticut (10).

C.

Canby, William M., Wilmington, Delaware (17).
*Carpenter, Thornton, Camden, South Carolina (7).
*Carpenter, William M., New Orleans, Louisiana (1).
Carrier, Joseph C., Notre Dame, Indiana (20).
Case, Leonard, Cleveland, Ohio (15).
Case, L. B., Richmond, Indiana (17).
*Case, William, Cleveland, Ohio (6).
Caswell, Alexis, Providence, Rhode Island (2).
Cattell, William C., Easton, Pennsylvania (15).
Chadbourne, P. A., Williamstown, Massachusetts (10).
Chandler, William H., New York, New York (19).
Chanute, O., Lawrence, Kansas (17).
Chapman, F. M., Chicago, Illinois (17).
*Chapman, N., Philadelphia, Pennsylvania (1).
Chase, Pliny E., Haverford, Pennsylvania (18).
Chase, R. Stuart, Haverhill, Massachusetts (18).
*Chase, S., Dartmouth, New Hampshire (2).
*Chauvenet, William, St. Louis, Missouri (1).
Chesbrough, E. S., Chicago, Illinois (2).
*Clapp, Asahel, New Albany, Indiana (1).
Clark, John E., Yellow Springs, Ohio (17).
*Clark, Joseph, Cincinnati, Ohio (5).
Clarke, F. W., Boston, Massachusetts (18).
*Cleveland, A. B., Cambridge, Massachusetts (2).
Coffin, James H., Easton, Pennsylvania (1).

Coffin, John H. C., Washington, District of Columbia (1).
Coffinberry, W. L., Grand Rapids, Michigan (20).
Cogswell, George, Bradford, Massachusetts (18).
Colbert, E., Chicago, Illinois (17).
*Cole, Thomas, Salem, Massachusetts (1).
*Coleman, Henry, Boston, Massachusetts (1).
Collett, John, Eugene, Indiana (17).
Cook, George H., New Brunswick, New Jersey (18).
Cooke, Caleb, Salem, Massachusetts (18).
Cope, Edward D., Philadelphia, Pennsylvania (17).
Copes, Joseph S., New Orleans, Louisiana (11).
*Corning, Erastus, Albany, New York (6).
Cox, Edward T., Indianapolis, Indiana (19).
Cramp, J. M., Wolfville, Nova Scotia (11).
*Crosby, Thomas R., Hanover, New Hampshire (18).
Culver, Howard Z., Chicago, Illinois (17).
Cummings, John, Woburn, Massachusetts (18).
Cummings, Joseph, Middletown, Connecticut (13).
Curtis, Josiah, Boston, Massachusetts (18).
Cutting, Hiram A., Lunenburg, Vermont (17).

D.

Dall, William H., Washington, District of Columbia (18).
Dalrymple, E. A., Baltimore, Maryland (11).
Dana, James D., New Haven, Connecticut (1).
Danforth, Edward, Albany, New York (11).
Davis, James, Boston, Massachusetts (1).
Davis, N. S., Chicago, Illinois (17).
Dawson, J. W., Montreal, Canada (10).
Day, F. H., Wauwatosa, Wisconsin (20).
*Dean, Amos, Albany, New York (6).
Dean, George W., Fall River, Massachusetts (15).
*Dearborn, George H. A. S., Roxbury, Massachusetts (1).
*Dekay, James E., New York, New York (1).
Delano, Joseph C., New Bedford, Massachusetts (5).
De Laski, John, Vinalhaven, Maine (18).
Devereux, J. H., Cleveland, Ohio (18).
*Dewey, Chester, Rochester, New York (1).
*Dexter, G. M., Boston, Massachusetts (11).
Dinwiddie, Robert, New York, New York (1).
Dixwell, Epes S., Cambridge, Massachusetts (1).
Dodd, C. M., Williamstown, Massachusetts (19).
Doggett, Kate N., Chicago, Illinois (17).
Doggett, William E., Chicago, Illinois (17).
Doughty, John W., Newburgh, New York (19).
Drowne, Charles, Troy, New York (6).
*Ducatel, J. T., Baltimore, Maryland (1).
*Dumont, A. H., Newport, Rhode Island (14).

*Duncan, Lucius C., New Orleans, Louisiana (10).
Duncan, T. C., Chicago, Illinois (17).
*Dunn, R. P., Providence, Rhode Island (14).
Dyer, Elisha, Providence, Rhode Island (9).

E.

Eaton, D. G., Brooklyn, New York (19).
Eaton, James H., Beloit, Wisconsin (17).
Edgar, George M., Franklin, Kentucky (20).
Edwards, A. M., Newark, New Jersey (18).
Eimbeck, William, St. Louis, Missouri (17).
Ellenwood, Charles N., San Francisco, California (18).
Elliott, Ezekiel B., Washington, District of Columbia (10).
Elwyn, Alfred L., Philadelphia, Pennsylvania (1).
Emerson, Benjamin K., Amherst, Massachusetts (19).
Emerson, George B., Boston, Massachusetts (1).
Emerton, James H., Salem, Massachusetts (18).
Englemann, George, St. Louis, Missouri (1).
Engstrom, A. B., Burlington, New Jersey (1).
Ennis, Jacob, Philadelphia, Pennsylvania (19).
Eustis, Henry L., Cambridge, Massachusetts (2).
Evans, Asher B., Lockport, New York (19).
*Everett, Edward, Boston, Massachusetts (2).
*Ewing, Thomas, Lancaster, Ohio (5).

F.

Fairbanks, Henry, St. Johnsbury, Vermont (14).
Farmer, Moses G., Salem, Massachusetts (9).
Farnham, Thomas, Buffalo, New York (15).
Fellowes, R. S., New Haven, Connecticut (18).
Fenton, William, Milwaukie, Wisconsin (18).
Ferrell, William, Cambridge, Massachusetts (11).
Ferris, Isaac, New York, New York (6).
Feuchtwanger, Louis, New York, New York (11).
Ficklin, Joseph, Columbia, Missouri (20).
Fishback, W. P., St. Louis, Missouri (20).
Fisher, Clark, Trenton, New Jersey (19).
Fisher, Davenport, Annapolis, Maryland (17).
Fisher, Mark, Trenton, New Jersey (10).
*Fitch, Alexander, Hartford, Connecticut (1).
Fitch, Edward H., Ashtabula, Ohio (11).
Fitch, O. H., Ashtabula, Ohio (7).
Fletcher, Ingram, Indianapolis, Indiana (20).
*Forbush, E. B., Buffalo, New York (15).
Ford, S. W., Troy, New York (19).
Forsyth, Robert, Troy, New York (19).

Foster, Henry, Clifton, New York (17).
Foster, John, Schenectady, New York (17).
Foster, J. W., Chicago, Illinois (1).
*Fox, Charles, Grosse Isle, Michigan (7).
Freeman, H. C., La Salle, Illinois (17).
Frothingham, Frederick, Buffalo, New York (11).

G.

Garman, S. W., Holly Springs, Mississippi (20).
Gavit, John E., New York, New York (1).
*Gay, Martin, Boston, Massachusetts (1).
*Gibbon, J. H., Charlotte, North Carolina (3).
Gill, Theodore, Washington, District of Columbia (17).
*Gillespie, W. M., Schenectady, New York (10).
Gilman, Daniel C., Oakland, California (10).
*Gilmor, Robert, Baltimore, Maryland (1).
Glazier, Sarah M., Chelsea, Massachusetts (19).
Goessman, C. A., Amherst, Massachusetts (18).
Gold, Theodore S., West Cornwall, Connecticut (4).
Goodell, Abner C., Jr., Salem, Massachusetts (18).
*Gould, Augustus A., Boston, Massachusetts (11).
*Gould, B. A., Boston, Massachusetts (2).
Gould, B. A., Cambridge, Massachusetts (2).
*Graham, James D., Washington, District of Columbia (1).
Gray, Asa, Cambridge, Massachusetts (1).
*Gray, James H., Springfield, Massachusetts (6).
Green, Traill, Easton, Pennsylvania (1).
*Greene, Benjamin D., Boston, Massachusetts (1).
Greene, Dascom, Troy, New York (17).
Greene, Francis C., Easthampton, Massachusetts (11).
Greer, James, Dayton, Ohio (20).
Gregory, J. J. H., Marblehead, Massachusetts (18).
*Griffith, Robert E., Philadelphia, Pennsylvania (1).
Grimes, J. S., Waukegan, Illinois (17).
Grinnan, A. G., Orange Court House, Virginia (7).
Griswold, John A., Troy, New York (19).
Guyot, Arnold, Princeton, New Jersey (1).

H.

*Hackley, Charles W., New York, New York (4).
Hadley, George, Buffalo, New York (6).
Hagen, Hermann A., Cambridge, Massachusetts (17).
Haldeman, S. S., Columbia, Pennsylvania (1).
*Hale, Enoch, Boston, Massachusetts (1).

Hale, William H., Albany, New York (19).
Hall, Benjamin H., Troy, New York (19).
Hall, George E., Cleveland, Ohio (19).
Hall, James, Albany, New York (1).
Hall, L. B., Windsor, Vermont (18).
Hall, N. K., Buffalo, New York (7).
Hambly, J. B., Portsmouth, Rhode Island (18).
Hamel, Thomas E., Quebec, Canada (18).
Hamlin, A. C., Bangor, Maine (10).
Hanaman, C. E., Troy, New York (19).
Hance, Ebenezer, Morrisville, Pennsylvania (7).
Hanover, M. D., Cincinnati, Ohio (13).
*Hare, Robert, Philadelphia, Pennsylvania (11).
*Harlan, Joseph G., Haverford, Pennsylvania (8).
*Harlan, Richard, Philadelphia, Pennsylvania (1).
*Harris, Thaddeus W., Cambridge, Massachusetts (1).
Harrison, B. F., Wallingford, Connecticut (11).
*Hart, Simeon, Farmington, Connecticut (1).
Hart, William H., Troy, New York (19).
Hartshorne, Henry, Philadelphia, Pennsylvania (12).
Harvey, Charles W., Greensburg, Indiana (20).
Hawkins, B. W., New York, New York (17).
*Hayden, H. H., Baltimore, Maryland (1).
Hayes, George E., Buffalo, New York (15).
*Hayward, James, Boston, Massachusetts (1).
Hedrick, B. S., Washington, District of Columbia (19).
Heimstreet, John W., Troy, New York (19).
Henry, Joseph, Washington, District of Columbia (1).
Hilgard, Eugene W., Oxford, Mississippi (11).
Hilgard, Julius E., Washington, District of Columbia (4).
Hilgard, Theodore C., St. Louis, Missouri (17).
Hill, S. W., Hancock, Lake Superior (6)..
Hill, Thomas, Portland, Maine (3).
Hinrichs, Gustavus, Iowa City, Iowa (17).
Hitchcock, Charles H., Hanover, New Hampshire (11).
*Hitchcock, Edward, Amherst, Massachusetts (1).
*Holbrook, J. E., Charleston, South Carolina (1).
Holley, A. L., Troy, New York (19).
Holley, George W., Niagara Falls, New York (19).
Holley, Miss E. P., Niagara Falls, New York (20).
Holmes, Thomas, Merom, Indiana (20).
Homes, Henry A., Albany, New York (11).
*Hopkins, Albert, Williamstown, Massachusetts (19).
Horribin, William T., Cohoes, New York (19).
Horsford, E. N., Cambridge, Massachusetts (1).
*Horton, William, Craigville, New York (1).
Hough, Franklin B., Lowville, New York (4).
Hough, G. W., Albany, New York (15).
*Houghton, Douglas, Detroit, Michigan (1).

House, John C., Waterford, New York (19).
Hovey, Edmund O., Crawfordsville, Indiana (20).
Hovey, Mary F., Crawfordsville, Indiana (20).
Howe, E. C., Yonkers, New York (19).
Howell, Robert, Nichols, New York (6).
Hoy, Philo R., Racine, Wisconsin (17).
Hubbard, Oliver P., New Haven, Connecticut (1).
Hubbard, Sara A., Chicago, Illinois (17).
*Hubbert, James, Richmond, Province of Quebec (16).
Humphrey, D., Lawrence, Massachusetts (18).
Humphreys, A. W., New York, New York (20).
*Hunt, E. B., Washington, District of Columbia (2).
*Hunt, Freeman, New York, New York (11).
Hunt, George, Providence, Rhode Island (9).
Hunt, T. Sterry, Boston, Massachusetts (1).
Huntington, J. H., Hanover, New Hampshire (19).
Hyatt, Alpheus, Salem, Massachusetts (18).
Hyatt, James, Bangall, New York (10).
Hyatt, Jonathan, Morrisania, New York (19).

I.

*Ives, Thomas P., Providence, Rhode Island (10).

J.

Jackson, C. L., Cambridge, Massachusetts (20).
Jasper, G. A., Charlestown, Massachusetts (18).
Jenks, J. W. P., Middleboro', Massachusetts (2).
Jillson, B. C., Pittsburg, Pennsylvania (14).
*Johnson, W. R., Washington, District of Columbia (1).
Johnston, John, Middletown, Connecticut (1).
*Jones, Catesby A. R., Washington, District of Columbia (8).
Joy, C. A., New York, New York (8).

K.

Keely, G. W., Waterville, Maine (1).
Kellogg, Giles B., Troy, New York (19).
Kellogg, Justin, Troy, New York (19).
Kennedy, Mary R., St. Louis, Michigan (19).
Kerr, W. C., Raleigh, North Carolina (10).
Kimball, J. P., New York, New York (15).
King, Mary B. A., Rochester, New York (15).
Kirkpatrick, James A., Philadelphia, Pennsylvania (7).
Kirkwood, Daniel, Bloomington, Indiana (7).
Kite, Thomas, Cincinnati, Ohio (5).

Klippart, John H., Columbus, Ohio (17).
Kneeland, Samuel, Boston, Massachusetts (20).
Knickerbocker, Charles, Chicago, Illinois (17).

L.

Lambert, Thomas R., Charlestown, Massachusetts (18).
Langley, S. P., Allegheny, Pennsylvania (18).
Lapham, Increase A., Milwaukie, Wisconsin (3).
*Lasel, Edward, Williamstown, Massachusetts (1).
Lattimore, S. A., Rochester, New York (15).
Lawrence, Edward, Charlestown, Massachusetts (18).
Lawrence, George N., New York, New York (7).
Lea, Isaac, Philadelphia, Pennsylvania (1).
Leakin, George A., Baltimore, Maryland (17).
Leckie, Robert G., Actonvale, Quebec (19).
*Lederer, Baron von, Washington, District of Columbia (1).
Lennon, W. H., Brockport, New York (19).
Lesley, Joseph, Jr., Philadelphia, Pennsylvania (8).
Lesley, J. P., Philadelphia, Pennsylvania (2).
*Lieber, Oscar M., Columbia, South Carolina (8).
*Lincklaen, Ledyard, Cazenovia, New York (1).
Lindsley, J. B., Nashville, Tennessee (1).
*Linsley, James H., Stafford, Connecticut (1).
Little, George, Oxford, Mississippi (15).
Locke, Erie, Indianapolis, Indiana (20).
Locke, Luther F., Nashua, New Hampshire (7).
Lockwood, Samuel, Freehold, New Jersey (18).
Logan, William E., Montreal, Canada (1).
Lombard, Benjamin, Chicago, Illinois (17).
Loomis, Elias, New Haven, Connecticut (1).
*Loosey, Charles F.. New York, New York (12).
*Lothrop, Joshua R., Buffalo, New York (15).
Lovering, Joseph, Cambridge, Massachusetts (2).
Lupton, N. T., Tuscaloosa, Alabama (17).
Lyman, B. S., Philadelphia, Pennsylvania (15).
Lyman, Chester S., New Haven, Connecticut (14).
Lyon, Henry, Charlestown, Massachusetts (18).

M.

Maack, G. A., Cambridge, Massachusetts (18).
MacArthur, Charles L., Troy, New York (19).
MacIntire, Thomas, Indianapolis, Indiana (20).
Mack, David, Belmont, Massachusetts (18).
Malone, David R., Edinburg, Indiana (20).
Marcy, Oliver, Evanston, Illinois (10).
Marden, George H., Charlestown, Massachusetts (18).

*Marsh, Dexter, Greenfield, Massachusetts (1).
*Mather, William W., Columbus, Ohio (1).
Mauran, J., New York, New York (2).
Mayer, Alfred M., Hoboken, New Jersey (19).
Mayhew, D. P., Ypsilanti, Michigan (18).
Maynard, George W., Troy, New York (10).
McCagg, Ezra B., Chicago, Illinois (17).
McClellan, R. H., Troy, New York (19).
*M'Conihe, Isaac, Troy, New York (4).
McMurtrie, Horace, Boston, Massachusetts (17).
McNeil, J. A., Grand Rapids, Michigan (18).
McRae, John, Camden, South Carolina (3).
McWhorter, Tyler, Aledo, Illinois (20).
*Meade, George G., Philadelphia, Pennsylvania (15).
Means, A., Oxford, Georgia (5).
Meehan, Thomas, Germantown, Pennsylvania (17).
Meek, F. B., Washington, District of Columbia (6).
Meigs, James A., Philadelphia, Pennsylvania (12).
Mendenhall, T. G., Columbus, Ohio (20).
Merritt, George, Indianapolis, Indiana (20).
Metcalf, Caleb B., Worcester, Massachusetts (20).
Minifie, William, Baltimore, Maryland (12).
Mitchell, Maria, Poughkeepsie, New York (4).
Mitchell, William H., Florence, Alabama (17).
Monroe, William, Boston, Massachusetts (18).
Moore, Joseph, Richmond, Indiana (20).
Morison, N. H., Baltimore, Maryland (17).
Morley, Edward W., Hudson, Ohio (18).
Morris, John G., Baltimore, Maryland (12).
Morris, Oran W., New York, New York (19).
Morse, Edward S., Salem, Massachusetts (18).
Morton, Henry, Hoboken, New Jersey (18).
*Morton, S. G., Philadelphia, Pennsylvania (1).
Myers, W. H., Fort Wayne, Indiana (17).

N.

Nason, Henry B., Troy, New York (13).
Nelson, Cleland K., Annapolis, Maryland (12).
Newberry, J. S., New York, New York (5).
Newcomb, Simon, Washington, District of Columbia (13).
Newman, John S., Indianapolis, Indiana (20).
*Newton, E. H., Cambridge, New York (1).
Newton, Hubert A., New Haven, Connecticut (6).
Newton, John, Mary-Esther, Florida (7).
Nichols, Charles A., Providence, Rhode Island (17).
Nichols, William R., Boston, Massachusetts (18).
Nickel, George D., Connellsville, Pennsylvania (19).

*Nicollett, J. N., Washington, District of Columbia (1).
Niles, W. H., Cambridge, Massachusetts (16).
*Norton, J. P., New Haven, Connecticut (1).
Norton, W. A., New Haven, Connecticut (6).

O.

*Oakes, William, Ipswich, Massachusetts (1).
O'Donnell, Emma, Lansingburg, New York (19).
Ogden, Mahlon D., Chicago, Illinois (17).
Ogden, W. B., Chicago, Illinois (17).
Oliver, James Edward, Ithaca, New York (7).
*Olmsted, Alexander F., New Haven, Connecticut (4).
*Olmsted, Denison, New Haven, Connecticut (1).
*Olmsted, Denison, Jr., New Haven, Connecticut (1).
Ordway, John M., Boston, Massachusetts (9).
Orton, Edward, Yellow Springs, Ohio (19).
Orton, James, Poughkeepsie, New York (18).
Osborne, A. O., Waterville, New York (19).
Osborne, Ada M., Waterville, New York (19).

P.

Packard, A. S., Jr., Salem, Massachusetts (16).
Page, Peter, Chicago, Illinois (17).
Paine, Cyrus F., Rochester, New York (12).
Paine, Nathaniel, Worcester, Massachusetts (18).
Painter, Minshall, Lima, Pennsylvania (7).
*Parkman, Samuel, Boston, Massachusetts (1).
Parmelee, Dubois D., New York, New York (15).
Parry, Charles C., Washington, District of Columbia (6).
Parvin, Theodore S., Iowa City, Iowa (7).
Patton, William W., Chicago, Illinois (18).
Peck, W. A., Troy, New York (19).
Peckham, S. F., Providence, Rhode Island (18).
Peirce, Benjamin, Cambridge, Massachusetts (1).
Peirce, B. O., Beverly, Massachusetts (18).
Perkins, George H., Burlington, Vermont (17).
Perkins, George R., Utica, New York (7).
*Perkins, Henry C., Newburyport, Massachusetts (18).
Perkins, Jr., S. E., Indianapolis, Indiana (20).
Perkins, Maurice, Schenectady, New York (15).
*Perry, John B., Cambridge, Massachusetts (16).
*Perry, M. C., New York, New York (10).
Phelps, Almira L., Baltimore, Maryland (13).
Phelps, Charles E., Baltimore, Maryland (13).
Phippen, George D., Salem, Massachusetts (18).
Pickering, Edward C., Boston, Massachusetts (18).

Pierce, H. A., Lansingburg, New York (19).
*Plumb, Ovid, Salisbury, Connecticut (9).
*Pope, Charles A., St. Louis, Missouri (12).
*Porter, John A., New Haven, Connecticut (14).
Pourtales, L. F., Washington, District of Columbia (1).
Pratt, William H., Davenport, Iowa (17).
Pruyn, J. V. L., Albany, New York (1).
*Pugh, Evan, Centre County, Pennsylvania (14).
Pumpelly, Raphael, Cambridge, Massachusetts (17).
Putnam, Adelaide M., Salem, Massachusetts (19).
Putnam, F. W., Salem, Massachusetts (10).

Q.

Quinche, A. J., Oxford, Mississippi (20).
Quincy, Edmund, Jr., Boston, Massachusetts (11).

R.

Rauch, J. H., Chicago, Illinois (11).
Raymond, R. W., New York, New York (15).
Read, Ezra, Terre Haute, Indiana (20).
Redfield, John H., Philadelphia, Pennsylvania (1).
*Redfield, William C., New York, New York (1).
Rice, William N., Middletown, Connecticut (18).
Richardson, F. C. A., Chicago, Illinois (20).
Riley, Charles V., St. Louis, Missouri (17).
Ritchie, E. S., Boston, Massachusetts (10).
Robertson, Thomas D., Rockford, Illinois (10).
Rochester, Thomas F., Buffalo, New York (15).
Rockwell, Alfred P., New Haven, Connecticut (10).
*Rockwell, John A., Norwich, Connecticut (10).
Rockwell, Joseph P., Boston, Massachusetts (17).
Rogers, Fairman, Philadelphia, Pennsylvania (11).
*Rogers, James B., Philadelphia, Pennsylvania (1).
Rogers, Robert E., Philadelphia, Pennsylvania (18).
Rogers, W. B., Boston, Massachusetts (1).
Rood, O. N., New York, New York (14).
Roosevelt, Clinton, New York, New York (11).
Rumsey, Bronson C., Buffalo, New York (15).
Runkle, J. D., Boston, Massachusetts (2).
Russell, L. W., Providence, Rhode Island (20).
Rutherford, Louis M., New York, New York (13).
Ryerson, Joseph T., Chicago, Illinois (17).

S.

Safford, J. M., Lebanon, Tennessee (6).
Safford, Truman H., Chicago, Illinois (13).
Samson, George W., New York, New York (18).
Sanders, Benjamin D., Wellsburg, West Virginia (19).
Saunders, William, London, Canada (17).
Scammon, J. Young, Chicago, Illinois (17).
Schanck, J. Stillwell, Princeton, New Jersey (4).
Schott, Charles A., Washington, District of Columbia (8).
Scudder, Samuel H., Boston, Massachusetts (13).
Seaman, Ezra C., Ann Arbor, Michigan (20).
Seely, Charles A., New York, New York (18).
Senter, Harvey S., Aledo, Illinois (20).
*Seward, William H., Auburn, New York (1).
Seymour, W. P., Troy, New York (19).
Shaler, N. S., Cambridge, Massachusetts (19).
Sheafer, P. W., Pottsville, Pennsylvania (4).
Sheldon, Edwin H., Chicago, Illinois (17).
Sherwood, Andrew, Mansfield, Pennsylvania (18).
Sias, Solomon, Charlotteville, New York (10).
Sill, Elisha N., Cuyahoga Falls, Ohio (6).
*Silliman, Benjamin, New Haven, Connecticut (1).
Silliman, Benjamin, New Haven, Connecticut (1).
Silliman, Justus M., Easton, Pennsylvania (19).
Sloan, John, New Albany, Indiana (20).
Smith, J. Lawrence, Louisville, Kentucky (14).
*Smith, J. V., Cincinnati, Ohio (5).
Smith, James Y., Providence, Rhode Island (9).
*Smith, Lyndon A., Newark, New Jersey (9).
Smith, Rollin A., Fond-du-Lac, Wisconsin (18).
Snell, Eben S., Amherst, Massachusetts (2).
*Sparks, Jared, Cambridge, Massachusetts (2).
Squier, E. G., New York, New York (18).
Stanard, Benjamin A., Cleveland, Ohio (6).
Stearns, R. E. C., San Francisco, California (18).
Steiner, Lewis H., Frederick City, Maryland (7).
Stephens, W. H., Lowville, New York (18).
Stevens, R. P., New York, New York (18).
Stimpson, Frederick E., Boston, Massachusetts (18).
Stimpson, Thomas M., Peabody, Massachusetts (18).
*Stimpson, William, Chicago, Illinois (12).
Stockwell, John N., Cleveland, Ohio (18).
Stone, Samuel, Chicago, Illinois (17).
Storer, D. H., Boston, Massachusetts (1).
Storer, Frank H., Boston, Massachusetts (13).
Storke, Helen L., Auburn, New York (19).

Stoughton, T. M., Factory Village, Massachusetts (18).
Strawbridge, William C., Elk-View, Pennsylvania (19).
*Sullivant, W. S., Columbus, Ohio (7).
Swallow, G. C., Columbia, Missouri (10).
Swasey, Oscar F., Beverly, Massachusetts (17).

T.

*Tallmadge, James, New York, New York (1).
Taylor, Edward R., Cleveland, Ohio (20).
*Taylor, Richard C., Philadelphia, Pennsylvania (1).
Tenney, Sanborn, Williamstown, Massachusetts (17).
*Teschemacher, J. E., Boston, Massachusetts (1).
Thompson, Aaron R., New York, New York (1).
Thompson, Harvey M., Chicago, Illinois (17).
Thompson, Robert H., Troy, New York (19).
*Thompson, Z., Burlington, Vermont (1).
*Thurber, Isaac, Providence, Rhode Island (9).
Tillman, Mrs. S. D., Jersey City, New Jersey (20).
Tillman, S. D., Jersey City, New Jersey (15).
Tingley, Joseph, Greencastle, Indiana (14).
Tolles, Robert B., Boston, Massachusetts (15).
*Torrey, John, New York, New York (1).
*Totten, J. G., Washington, District of Columbia (1).
Townsend, Franklin, Albany, New York (4).
*Townsend, John K., Philadelphia, Pennsylvania (1).
Townshend, N. S., Avon, Ohio (17).
Tracy, C. M., Lynn, Massachusetts (19).
Treat, Joseph, Vineland, New Jersey (19).
Trembly, J. B., Toledo, Ohio (17).
*Troost, Gerard, Nashville, Tennessee (1).
Trowbridge, W. P., New Haven, Connecticut (10).
*Tuomey, M., Tuscaloosa, Alabama (1).
Turner, R. S., St. Paul, Minnesota (18).
Tuttle, Albert H., Cleveland, Ohio (17).
Twining, A. C., New Haven, Connecticut (18).
*Tyler, Edward R., New Haven, Connecticut (1).
Tyson, Philip T., Baltimore, Maryland (12).

U.

Uhler, Philip R., Baltimore, Maryland (19).
Upham, J. Baxter, Boston, Massachusetts (14).

V.

Vail, Hugh D., Philadelphia, Pennsylvania (18).
*Vancleve, John W., Dayton, Ohio (1).

Van der Weyde, P. H., New York, New York (17).
Van Horne, W. C., Chicago, Illinois (19).
*Vanuxem, Lardner, Bristol, Pennsylvania (1).
Vaux, William S., Philadelphia, Pennsylvania (1).
Vose, George L., Brunswick, Maine (15).

W.

Waddel, John N., Oxford, Mississippi (17).
*Wadsworth, James S., Genesee, New York (2).
*Wagner, Tobias, Philadelphia, Pennsylvania (9).
Walker, Charles A., Chelsea, Massachusetts (18).
Walker, George C., Chicago, Illinois (17).
Walker, J. R., New Orleans, Louisiana (19).
*Walker, Joseph, Oxford, New York (10).
*Walker, Sears C., Washington, District of Columbia (1).
*Walker, Timothy, Cincinnati, Ohio (4).
Walling, H. F., Boston, Massachusetts (16).
Wanzer, Ira, Lanesville, Connecticut (18).
Ward, Henry A., Rochester, New York (18).
Ward, R. H., Troy, New York (17).
Warder, Robert B., Cleves, Ohio (19).
Wardwell, George J., Rutland, Vermont (20).
Warner, James D., Brooklyn, New York (18).
Warren, G. K., Washington, District of Columbia (12).
Warren, G. W., Boston, Massachusetts (18).
*Warren, John C., Boston, Massachusetts (1).
Warren, S. Edward, Boston, Massachusetts (17).
Watson, William, Boston, Massachusetts (12).
Webb, Benjamin, Jr., Salem, Massachusetts (18).
*Webster, H. B. Albany, New York (1).
*Webster, J. W., Cambridge, Massachusetts (1).
*Webster, M. H., Albany, New York (1).
Webster, Nathan B., Norfolk, Virginia (7).
Wells, Daniel H., New Haven, Connecticut (18).
Wells, George A., Troy, New York (19).
Wendell, August, Troy, New York (19).
West, Charles E., Brooklyn, New York (1).
Wheatland, Henry, Salem, Massachusetts (1).
*Wheatland, Richard H., Salem, Massachusetts (13).
Wheatley, Charles M., Phœnixville, Pennsylvania (1).
Wheeler, C. G., Chicago, Illinois (18).
Wheeler, T. B., Montreal, Canada (11).
Wheildon, W. W., Concord, Massachusetts (13).
White, C. A., Iowa City, Iowa (17).
Whitfield, R. P., Albany, New York (18).
Whitney, Asa, Philadelphia, Pennsylvania (1).

Whitney, J. D., Cambridge, Massachusetts (1).
Whitney, Mary W., Waltham, Massachusetts (19).
Whitney, Solon F., Watertown, Massachusetts (20).
Whittlesey, Charles, Cleveland, Ohio (1).
Wilber, G. M., Pine Plains, New York (19).
*Willard, Emma, Troy, New York (15).
Williams, H. S., New Haven, Connecticut (18).
Williams, Henry W., Boston, Massachusetts (11).
Williams, J. G., Detroit, Michigan (19).
Williamson, R. S., San Francisco, California (12).
Winchell, Alexander, Syracuse, New York (3).
Winchell, N. H., St. Anthony, Minnesota (19).
Winslow, Ferdinand S., Chicago, Illinois (17).
*Woodbury, L., Portsmouth, New Hampshire (1).
Woodworth, John M., Washington, District of Columbia (17).
Wormley, Thomas G., Columbus, Ohio (20).
Worthen, A. H., Springfield, Illinois (5).
Wright, A. W., Williamstown, Massachusetts (14).
Wright, Chauncey, Cambridge, Massachusetts (9).
*Wright, John, Troy, New York (1).
Wurtele, Louis C., Acton Vale, Canada East (11).
Wurtz, Henry, New York, New York (10).

Y.

Youmans, E. L., New York, New York (6).
Young, Charles A., Hanover, New Hampshire (18).
*Young, Ira, Hanover, New Hampshire (7).
Young, William H., Troy, New York (19).

This list contains six hundred and fifty-one names, of which one hundred and thirty-four are of deceased members. The names of those who were chosen at Dubuque, and who have already joined the Association, have not yet been incorporated into the general catalogue of members, but are printed separately.

MEMBERS

WHO JOINED AT

THE DUBUQUE MEETING.

Adcock, Robert J., Lenox, Illinois.
Addams, Miss Alice S., Cedarville, Illinois.
Arthur, J. C., Ames, Iowa.

Barrett, Moses, Milwaukie, Wisconsin.
Bass, George, Noblesville, Indiana.
Beach, W. H., Dubuque, Iowa.
Beach, Myron H., Dubuque, Iowa.
Bebb, Michael, Fountaindale, Iowa.
Bessey, C. E., Ames, Iowa.
Blodgett, James H., Rockford, Illinois.
Bryant, W. M., Burlington, Iowa.
Bush, Alva, Osage, Iowa.

Carmichael, Henry, Grinnell, Iowa.
Chamberlain, T. C., Whitewater, Wisconsin.
Collins, Alonzo, Mount Vernon, Iowa.
Comstock, M. L., Galesbury, Illinois.
Conser, E. P., Sandsprings, Iowa.
Crawford, John S., Galena, Illinois.
Crocker, Susan E., Lawrence, Massachusetts.
Curtis, W. S., Rockford, Illinois.

Darby, John, Millersburg, Kentucky.
Davenport, Mrs. M. G., Oskaloosa, Iowa.
De Camp, William D., Grand Rapids, Michigan.
Downer, Henry E., Detroit, Michigan.

Edwards, Thomas C., Vineland, New Jersey.
Everett, O., Dixon, Illinois.

Faries, R. J., Wauwatoso, Wisconsin.
Fluegel, Maurice, Quincy, Illinois.
Foote, A. E., Agricultural College, Iowa.
Forshey, C. S., New Orleans, Louisiana.
Fulton, R. B., Oxford, Mississippi.

Graves, G. A., Ackley, Iowa.
Griffith, E. A., Mount Pleasant, Iowa.

Harwood, Grace, Council Hill, Illinois.
Henderson, G. L., Le Roy, Minnesota.
Horr, Asa, Dubuque, Iowa.
Hovey, Mary C., Crawfordsville, Indiana.

Irish, T. M., Dubuque, Iowa.

Jones, William P., Ravenswood, Illinois.

King, Robert, Kalamazoo, Michigan.
King, William F., Mount Vernon, Iowa.
Kinner, Hugo, St. Louis, Missouri.
Knepper, C. O., Waverly, Iowa.
Knight, J. B., New Orleans, Louisiana.
Knox, Otho S., Waterloo, Iowa.

Lambert, T. S., New York, New York.
Leonard, N. R., Iowa City, Iowa.
Loughridge, Albert, Newton, Iowa.
Loughridge, R. H., Oxford, Mississippi.

Mack, William, Salem, Massachusetts.
Mark, Edward L., Fredonia, New York.
McCreery, J. L., Dubuque, Iowa.
McIsaac, P., Waterloo, Iowa.

Newman, Eliza J., Indianapolis, Indiana.
Nicholson, Thomas, New Orleans, Louisiana.
Norton, Mary E. B., Rockford, Illinois.
*Noyes, J. O., New Orleans, Louisiana.

Ogden, Robert W., New Orleans, Louisiana.
Ostrander, L. A., Dubuque, Iowa.

Palfrey, C. W., Salem, Massachusetts.
Palmer, A. B., Ann Arbor, Michigan.
Palmer, B. M., New Orleans, Louisiana.
Palmer, Mrs. L. M., Ann Arbor, Michigan
Parker, J. B., Grand Rapids, Michigan.

Percival, C. S., Independence, Iowa.
Preston, W. C., Iowa City, Iowa.
Pulsifer, Sidney, Peoria, Illinois.

Rominger, Carl, Ann Arbor, Michigan.
Ross, Alexander Milton, Toronto, Canada.

Safford, Mary J., Chicago, Illinois.
Saunderson, Robert, Burlington, Iowa.
Smith, J. W., Charles City, Iowa.
Starr, William, Ripon, Wisconsin.
Stephens, Julius, Springvale, Illinois.
Steward, A., Dubuque, Iowa.
Stuart, A. P. S., Champaign, Iowa.
Stowell, John, Charlestown, Massachusetts.
Swain, James, Fort Dodge, Iowa.
Swain, Mrs. James, Fort Dodge, Iowa.
Swan, R. W., Grinnell, Iowa.

Taft, Mary A., Springvale, Iowa.
Taft, S. H., Springvale, Iowa.
Thomson, A., Iowa City, Iowa.
Thrasher, William M., Indianapolis, Indiana.
Trowbridge, Mrs. L. H., Kalamazoo, Michigan.

Warner, H. C., Clairmont, Iowa.
Warner, Mrs. J. D., Brooklyn, New York.
Waugh, J. W., Lucknow, India.
Welch, Miss G. O., Lynn, Massachusetts.
Westcott, O. S., Chicago, Illinois.
Wiley, H. W., Indianapolis, Indiana.
Williams, Mrs. E. B., Strawberry Point, Iowa.
Witter, F. M., Muscatine, Iowa.

MEMBERS

WHO JOINED AT

THE INDIANAPOLIS MEETING.

Abbot, Elizabeth O., Providence, Rhode Island.
Alexander, John S., Philadelphia, Pennsylvania.
Austin, Thomas R., Terre Haute, Indiana.
Aydelotte, William, Sullivan, Indiana.

Barnard, Jehiel, Indianapolis, Indiana.
Bell, Eliza C., Indianapolis, Indiana.
Berry, Daniel M., Indianapolis, Indiana.
Billingsley, J. J. W., Spring Valley, Indiana.
Bowman, Thomas, Greencastle, Indiana.
Braden, William, Indianapolis, Indiana.
Buckhout, W. A., Agricultural College, Pennsylvania.
Bullard, William M., Indianapolis, Indiana.
Burford, William B., Indianapolis, Indiana.

Carrington, Henry B., Crawfordsville, Indiana.
Carson, James P., New York, New York.
Colgan, Charles J., Indianapolis, Indiana.
Coulson, Mary, Mason, Ohio.

Dana, Charles P., New York, New York.
Davis, F. A. W., Indianapolis, Indiana.
Day, Henry, Indianapolis, Indiana.
Day, Henry, Indianapolis, Indiana.
Dodge, Anna, Indianapolis, Indiana.
Dolbear, A. Emerson, Bethany, West Virginia.

Edwards, William K., Terre Haute, Indiana.
Elliott, Thomas B., Indianapolis, Indiana.
English, Rose, Indianapolis, Indiana.

English, William E., Indianapolis, Indiana.
English, William H., Indianapolis, Indiana.

Farlow, W. G., Cambridge, Massachusetts.
Ferguson, James, Ashboro', Indiana.
Fisher, Clark, Trenton, New Jersey.
Fletcher, William B., Indianapolis, Indiana.

Gilpatrick, John L., Gosport, Indiana.
Gordon, George E., Indianapolis, Indiana.

Hagar, Albert D., St. Louis, Missouri.
Hawley, C. T., Milwaukie, Wisconsin.
Hawley, R. E., Cincinnati, Ohio.
Hill, J. A., Greencastle, Indiana.
Hobbs, William Henry, Indianapolis, Indiana.
Hopkins, Frederick V., Baton Rouge, Louisiana.
Hosford, Charles E., Terre Haute, Indiana.
Hunt, Sarah E., Salem, Massachusetts.
Hunter, Morton C., Bloomington, Indiana.

Kinder, Sarah, Indianapolis, Indiana.

Landon, S. D., Attica, Indiana.
Lyon, James A., Oxford, Mississippi.
*Lyon, Sidney S., Jeffersonville, Indiana.

McChesney, Joseph H., Chicago, Illinois.
McDonald, J. D., Attica, Indiana.
McKeen, William R., Terre Haute, Indiana.
McRae, Hamilton S., Muncie, Indiana.
Mills, Isaac F., Wabash, Indiana.
Mills, Joseph J., Wabash, Indiana.
Minshall, D. W., Terre Haute, Indiana.

Nutt, Cyrus, Bloomington, Indiana.

Owen, Richard, Bloomington, Indiana.

Parker, Lucy H., Cincinnati, Ohio.
Parvin, Theophilus, Indianapolis, Indiana.
Pierce, Henry D., Indianapolis, Indiana.
Poole, Henry S., Nova Scotia.
Poole, Joseph, Attica, Indiana.

Reed, Edmund B., London, Canada.
Robertson, Robert S., Fort Wayne, Indiana.
Rockwood, Charles G., Brunswick, Maine.
Rogers, Joseph G., Madison, Indiana.

Salter, James W., Richmond, Indiana.
Scott, Harvey D., Terre Haute, Indiana.
Smith, Eugene A., Tuscaloosa, Alabama.
Smith, T. Guilford, Philadelphia, Pennsylvania.
Spencer, John W., Paxton, Indiana.
Stearns, Thaddeus M., Indianapolis, Indiana.
Storrs, Henry E., Jacksonville, Illinois.
Stott, W. T., Franklin, Indiana.
Sutton, George, Aurora, Indiana.

Tappan, Eli T., Gambier, Ohio.
Taylor, Franklin, Indianapolis, Indiana.
Thomas, Norbourn, Terre Haute, Indiana.
Thompson, James, Bloomington, Indiana.
Todd, Charles N., Indianapolis, Indiana.
Tomlinson, J. M., Indianapolis, Indiana.
Tuell, William B., Terre Haute, Indiana.

Vasey, George, Normal, Illinois.

Wahl, W. H., Philadelphia, Pennsylvania.
Walker, Joseph B., Louisville, Kentucky.
Walker, N. B., Arlington, Massachusetts.
Wardwell, George J., Rutland, Vermont.
Wheat, J. J., Oxford, Mississippi.
Wiley, Philander, Greencastle, Indiana.
Williams, W. D., Macon, Georgia.
Wilson, Joseph R., Columbia, South Carolina.
Woodman, H. T., Dubuque, Iowa.
Wright, John C., Indianapolis, Indiana.
Wyckoff, William C., New York, New York.
Wylie, Theophilus A., Bloomington, Indiana.

ADDRESS

OF

PROFESSOR ASA GRAY,

EX-PRESIDENT OF THE ASSOCIATION.

GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:—

THE session being now happily inaugurated, your presiding officer of the last year has only one duty to perform before he surrenders his chair to his successor. If allowed to borrow a simile from the language of my own profession, I might liken the President of this Association to a biennial plant. He flourishes for the year in which he comes into existence, and performs his appropriate functions as presiding officer. When the second year comes round, he is expected to blossom out in an address and disappear. Each President, as he retires, is naturally expected to contribute something from his own investigations or his own line of study, usually to discuss some particular scientific topic.*

Now, although I have cultivated the field of North American Botany, with some assiduity, for more than forty years, have reviewed our vegetable hosts, and assigned to no small number of them their names and their place in the ranks, yet, so far as our own wide country is concerned, I have been to a great extent a

* This discourse having been written *en route*, from scanty notes, far away from books or other means of verification, and printed directly after delivery in the "American Naturalist," and in the "American Journal of Science and the Arts," as well as elsewhere, it has naturally happened that some statements required correction or qualification. A few alterations which seemed to be needed are now made, and an Appendix is added.

closet botanist. Until this summer I had not seen the Mississippi, nor set foot upon a prairie.

To gratify a natural interest, and to gain some title for addressing a body of practical naturalists and explorers, I have made a pilgrimage across the continent. I have sought and viewed in their native haunts many a plant and flower which for me had long bloomed unseen, or only in the *hortus siccus*. I have been able to see for myself what species and what forms constitute the main features of the vegetation of each successive region, and record — as the vegetation unerringly does — the permanent characteristics of its climate.

Passing on from the eastern district, marked by its equably distributed rainfall, and therefore naturally forest-clad, I have seen the trees diminish in number, give place to wide prairies, restrict their growth to the borders of streams, and then disappear from the boundless drier plains; have seen grassy plains change into a brown and sere desert, — desert in the common sense, but hardly anywhere botanically so; have seen a fair growth of coniferous trees adorning the more favored slopes of a mountain range high enough to compel summer showers; have traversed that broad and bare elevated region shut off on both sides by high mountains from the moisture supplied by either ocean, and longitudinally intersected by sierras which seemingly remain as naked as they were born; and have reached at length the westward slopes of the high mountain barrier which, refreshed by the Pacific, bear the noble forests of the Sierra Nevada and the Coast Range, and among them trees which are the wonder of the world. As I stood in their shade, in the groves of Mariposa and Calaveras, and again under the canopy of the commoner Redwood, raised on columns of such majestic height and ample girth, it occurred to me that I could not do better than to share with you, upon this occasion, some of the thoughts which possessed my mind. In their development they may, perhaps, lead us up to questions of considerable scientific interest.

I shall not detain you with any remarks — which would now be trite — upon the size or longevity of these far-famed Sequoia trees, or of the Sugar Pines, Incense-Cedar, and Firs associated with them, of which even the prodigious bulk of the dominating Sequoia does not sensibly diminish the grandeur. Although no account and no photographic representation of either species of the far-famed Sequoia trees gives any adequate impression of their singular

majesty — still less of their beauty — yet my interest in them did not culminate merely or mainly in considerations of their size and age. Other trees, in other parts of the world, may claim to be older. Certain Australian Gum-trees (Eucalypti) are said to be taller. Some, we are told, rise so high that they might even cast a flicker of shadow upon the summit of the pyramid of Cheops. Yet the oldest of them doubtless grew from seed which was shed long after the names of the pyramid-builders had been forgotten. So far as we can judge from the actual counting of the layers of several trees, no Sequoia now alive can sensibly antedate the Christian era.

Nor was I much impressed with an attraction of man's adding. That the more remarkable of these trees should bear distinguishing appellations seems proper enough; but the tablets of personal names which are affixed to many of them in the most visited groves — as if the memory of more or less notable people of our day might be made more enduring by the juxtaposition — do suggest some incongruity. When we consider that a hand's breadth at the circumference of any one of the venerable trunks so placarded has recorded in annual lines the lifetime of the individual thus associated with it, one may question whether the next hand's breadth may not measure the fame of some of the names thus ticketed for adventitious immortality. Whether it be the man or the tree that is honored in the connection, probably either would live as long, in fact and in memory, without it.

One notable thing about these Sequoia trees is their *isolation*. Most of the trees associated with them are of peculiar species, and some of them are nearly as local. Yet every Pine, Fir, and Cypress in California is in some sort familiar, because it has near relatives in other parts of the world. But the Redwoods have none. The Redwood — including in that name the two species of "big-trees" — belongs to the general Cypress family, but is *sui generis*. Thus isolated sytematically, and extremely isolated geographically, and so wonderful in size and port, they more than other trees suggest questions.

Were they created thus local and lonely, denizens of California only; one in limited numbers in a few choice spots on the Sierra Nevada, the other along the coast range from the Bay of Monterey to the frontiers of Oregon? Are they veritable Melchizedeks, without pedigree or early relationship, and possibly fated to be without descent?

Or are they now coming upon the stage — or rather were they coming but for man's interference — to play a part in the future?

Or are they remnants, sole and scanty survivors of a race that has played a grander part in the past, but is now verging to extinction? Have they had a career, and can that career be ascertained or surmised, so that we may at least guess whence they came, and how, and when?

Time was, and not long ago, when such questions as these were regarded as useless and vain, — when students of natural history, unmindful of what the name denotes, were content with a knowledge of things as they now are, but gave little heed as to how they came to be so. Now, such questions are held to be legitimate, and perhaps not wholly unanswerable. It cannot now be said that these trees inhabit their present restricted areas simply because they are there placed in the climate and soil of all the world most congenial to them. These must indeed be congenial, or they would not survive. But when we see how Australian Eucalyptus trees thrive upon the Californian coast, and how these very Redwoods flourish upon another continent; how the so-called wild oat (Avena sterilis of the Old World) has taken full possession of California; how that cattle and horses, introduced by the Spaniard, have spread as widely and made themselves as much at home on the plains of La Plata as on those of Tartary; and that the cardoon-thistle seeds, and others they brought with them, have multiplied there into numbers probably much exceeding those extant in their native lands; indeed, when we contemplate our own race, and our own particular stock, taking such recent but dominating possession of this New World; when we consider how the indigenous flora of islands generally succumbs to the foreigners which come in the train of man; and that most weeds (*i.e.*, the prepotent plants in open soil) of all temperate climates are not "to the manner born," but are self-invited intruders, — we must needs abandon the notion of any primordial and absolute adaptation of plants and animals to their habitats, which may stand in lieu of explanation, and so preclude our inquiring any further. The harmony of Nature and its admirable perfection need not be regarded as inflexible and changeless. Nor need Nature be likened to a statue, or a cast in rigid bronze, but rather to an organism, with play and adaptability of parts, and life and even soul informing the whole. Under the former view Nature would be "the faultless monster which the world ne'er saw," but inscrutable as the Sphinx, whom

it were vain, or worse, to question of the whence and whither. Under the other, the perfection of nature, if relative, is multifarious and ever renewed; and much that is enigmatical now may find explanation in some record of the past.

That the two species of Redwood we are contemplating originated as they are and where they are, and for the part they are now playing, is, to say the least, not a scientific supposition, nor in any sense a probable one. Nor is it more likely that they are destined to play a conspicuous part in the future, or that they would have done so, even if the Indian's fires and the white man's axe had spared them. The Redwood of the coast (Sequoia sempervirens) had the stronger hold upon existence, forming as it did large forests throughout a narrow belt about three hundred miles in length, and being so tenacious of life that every large stump sprouts into a copse. But it does not pass the Bay of Monterey, nor cross the line of Oregon, although so grandly developed not far below it. The more remarkable Sequoia gigantea of the Sierra exists in numbers so limited that the separate groves may be reckoned upon the fingers, and the trees of most of them have been counted, except near their southern limit, where they are said to be more copious. A species limited in individuals holds its existence by a precarious tenure; and this has a foothold only in a few sheltered spots, of a happy mean in temperature, and locally favored with moisture in summer. Even there, for some reason or other, the Pines with which they are associated (Pinus Lambertiana and P. ponderosa), the Firs (Abies grandis and A. amabilis) and even the Incense-Cedar (Libocedrus decurrens) possess a great advantage, and, though they strive in vain to emulate their size, wholly overpower the Sequoias in numbers. "To him that hath shall be given." The force of numbers eventually wins. At least in the commonly visited groves Sequoia gigantea is invested in its last stronghold, can neither advance into more exposed positions above, nor fall back into drier and barer ground below, nor hold its own in the long-run where it is, under present conditions; and a little further drying of the climate, which must once have been much moister than now, would precipitate its doom. Whatever the individual longevity, certain if not speedy is the decline of a race in which a high death-rate afflicts the young. Seedlings of the big trees occur not rarely, indeed, but in meagre proportion to those of associated trees; and small indeed is the chance that any of these will attain to "the days of the years of their fathers."

"Few and evil" are the days of all the forest likely to be, while man, both barbarian and civilized, torments them with fires, fatal at once to seedlings, and at length to the aged also. The forests of California, proud as the State may be of them, are already too scanty and insufficient for her uses. Two lines, such as may be drawn with one sweep of a brush over the map, would cover them all. The coast Redwood — the most important tree in California, although a million times more numerous than its relative of the Sierra — is too good to live long. Such is its value for lumber and its accessibility, that, judging the future by the past, it is not likely, in its primeval growth, to outlast its rarer fellow-species.

Happily man preserves and disseminates as well as destroys. The species will doubtless be preserved to science, and for ornamental and other uses, in its own and other lands; and the more remarkable individuals of the present day are likely to be sedulously cared for, all the more so as they become scarce.

Our third question remains to be answered: Have these famous Sequoias played in former times and upon a larger stage a more imposing part, of which the present is but the epilogue? We cannot gaze high up the huge and venerable trunks, which one crosses the continent to behold, without wishing that these patriarchs of the grove were able, like the long-lived antediluvians of Scripture, to hand down to us, through a few generations, the traditions of centuries, and so tell us somewhat of the history of their race. Fifteen hundred annual layers have been counted, or satisfactorily made out, upon one or two fallen trunks. It is probable that close to the heart of some of the living trees may be found the circle that records the year of our Saviour's nativity. A few generations of such trees might carry the history a long way back. But the ground they stand upon, and the marks of very recent geological change and vicissitude in the region around, testify that not very many such generations can have flourished just there, at least in an unbroken series. When their site was covered by glaciers, these Sequoias must have occupied other stations, if, as there is reason to believe, they then existed in the land.

I have said that the Redwoods have no near relatives in the country of their abode, and none of their genus anywhere else. Perhaps something may be learned of their genealogy by inquiring of such relatives as they have. There are only two of any particular nearness of kin; and they are far away. One is the Bald Cypress, our southern Cypress, Taxodium, inhabiting the swamps

of the Atlantic coast from Maryland to Texas, thence extending—with, probably, a specific difference—into Mexico. It is well known as one of the largest trees of our Atlantic forest-district, and, although it never—except perhaps in Mexico, and in rare instances—attains the portliness of its western relatives, yet it may equal them in longevity. The other relative is Glyptostrobus, a sort of modified Taxodium, being about as much like our Bald Cypress as one species of Redwood is like the other.

Now species of the same type, especially when few, and the type peculiar, are, in a general way, associated geographically, *i.e.*, inhabit the same country, or (in a large sense) the same region. Where it is not so, where near relatives are separated, there is usually something to be explained. Here is an instance. These four trees, sole representatives of their tribe, dwell almost in three separate quarters of the world: the two Redwoods in California, the Bald Cypress in Atlantic North America, its near relative, Glyptostrobus, in China.

It was not always so. In the tertiary period, the geological botanists assure us, our own very Taxodium or Bald Cypress, and a Glyptostrobus, exceedingly like the present Chinese tree, and more than one Sequoia, co-existed in a fourth quarter of the globe, viz., in Europe! This brings up the question: Is it possible to bridge over these four wide intervals of space and the much vaster interval of time, so as to bring these extraordinarily separated relatives into connection? The evidence which may be brought to bear upon this question is various and widely scattered. I bespeak your patience while I endeavor to bring together, in an abstract, the most important points of it.

Some interesting facts may come out by comparing generally the botany of the three remote regions, each of which is the sole home of one of these genera, *i.e.*, Sequoia in California, Taxodium in the Atlantic United States,* and Glyptostrobus in China, which compose the whole of the peculiar tribe under consideration.

Note then, first, that there is another set of three or four peculiar trees, in this case of the Yew family, which has just the same peculiar distribution, and which therefore may have the same ex-

* The phrase, "Atlantic United States," is here used throughout in contradistinction to Pacific United States: to the former of course belongs, botanically and geographically, the valley of the Mississippi and its tributaries up to the eastern border of the great woodless plains, which constitute an intermediate region.

planation, whatever that explanation be. The genus Torreya, which commemorates our botanical Nestor and a former President of this association, Dr. Torrey, was founded upon a tree rather lately discovered (that is, about thirty-five years ago) in Northern Florida. It is a noble, yew-like tree, and very local, being, so far as known, nearly confined to a few miles along the shores of a single river. It seems as if it had somehow been crowded down out of the Alleghanies into its present limited southern quarters; for in cultivation it evinces a northern hardiness. Now another species of Torreya is a characteristic tree of Japan; and one very like it, if not the same, inhabits the mountains of Northern China,—belongs, therefore, to the eastern Asiatic temperate region, of which Northern China is a part, and Japan, as we shall see, the portion most interesting to us. There is only one more species of Torreya, and that is a companion of the Redwoods in California. It is the tree locally known under the name of the California Nutmeg. Here are three or four near brethren, species of the same genus, known nowhere else than in these three habitats.

Moreover, the Torreya of Florida is associated with a Yew; and the trees of this grove are the only Yew-trees of Eastern North America; for the Yew of our northern woods is a decumbent shrub. A Yew-tree, perhaps the same, is found with Taxodium in the temperate parts of Mexico. The only other Yews in America grow with the Redwoods and the other Torreya in California, and extend northward into Oregon. Yews are also associated with Torreya in Japan; and they extend westward through Mandchuria and the Himalayas to Western Europe, and even to the Azores Islands, where occurs the common Yew of the Old World.

So we have three groups of coniferous trees which agree in this peculiar geographical distribution, with, however, a notable extension of range in the case of the Yew: first, the Redwoods, and their relatives, Taxodium and Glyptostrobus, which differ so as to constitute a genus for each of the three regions; second, the Torreyas, more nearly akin, merely a different species in each region; third, the Yews, still more closely related while more widely disseminated, of which it is yet uncertain whether they constitute seven, five, three, or only one species. Opinions differ, and can hardly be brought to any decisive test. However it be determined, it may still be said that the extreme differences among the Yews do not surpass those of the recognized variations of the European Yew, the cultivated races included.

It appears to me that these several instances all raise the very same question, only with different degrees of emphasis, and, if to be explained at all, will have the same kind of explanation.

Continuing the comparison between the three regions with which we are concerned, we note that each has its own species of Pines, Firs, Larches, &c., and of a few deciduous-leaved trees, such as Oaks and Maples; all of which have no peculiar significance for the present purpose, because they are of genera which are common all round the northern hemisphere. Leaving these out of view, the noticeable point is that the vegetation of California is most strikingly unlike that of the Atlantic United States. They possess some plants, and some peculiarly American plants in common, — enough to show, as I imagine, that the difficulty was not in the getting from the one district to the other, or into both from a common source, but in abiding there. The primordially unbroken forest of Atlantic North America, nourished by rainfall distributed throughout the year, is widely separated from the western region of sparse and discontinuous tree-belts of the same latitude on the western side of the continent, where summer rain is wanting, or nearly so, by immense treeless plains and plateaux of more or less aridity, traversed by longitudinal mountain ranges of a similar character. Their nearest approach is at the north, in the latitude of Lake Superior, where, on a more rainy line, trees of the Atlantic forest and that of Oregon may be said to interchange. The change of species and of the aspect of vegetation in crossing, say on the forty-seventh parallel, is slight in comparison with that on the thirty-seventh or near it. Confining our attention to the lower latitude, and under the exceptions already specially noted, we may say that almost every characteristic form in the vegetation of the Atlantic States is wanting in California, and the characteristic plants and trees of California are wanting here.

California has no Magnolia nor Tulip trees, nor Star-anise-tree; no so-called Papaw (Asimina); no Barberry of the common single-leaved sort; no Podophyllum or other of the peculiar associated genera; no Nelumbo nor White Water-lily; no Prickly Ash nor Sumach; no Loblolly-bay nor Stuartia; no Basswood nor Linden-trees; neither Locust, Honey-locust, Coffee-trees (Gymnocladus) nor Yellow-wood (Cladrastis); nothing answering to Hydrangea or Witch-hazel, to Gum-trees (Nyssa and Liquidambar), Viburnum or Diervilla; it has few Asters and Golden-rods; no Lobelias; no

Huckleberries and hardly any Blueberries; no Epigæa, charm of our earliest eastern spring, tempering an icy April wind with a delicious wild fragrance; no Kalmia nor Clethra, nor Holly, nor Persimmon; no Catalpa-tree, nor Trumpet-creeper (Tecoma); nothing answering to Sassafras, nor to Benzoin-tree, nor to Hickory; neither Mulberry nor Elm; no Beech, true Chestnut, Hornbeam, nor Ironwood, nor a proper Birch-tree; and the enumeration might be continued very much further by naming herbaceous plants and others familiar only to botanists.

In their place California is filled with plants of other types,—trees, shrubs, and herbs, of which I will only remark that they are, with one or two exceptions, as different from the plants of the eastern Asiatic region with which we are concerned (Japan, China, and Mandchuria), as they are from those of Atlantic North America. Their near relatives, when they have any in other lands, are mostly southward, on the Mexican plateau, or many as far south as Chili. The same may be said of the plants of the intervening great plains, except that northward and in the subsaline vegetation there are some close alliances with the flora of the steppes of Siberia. And along the crests of high mountain ranges the arctic-alpine flora has sent southward more or less numerous representatives through the whole length of the country.

If we now compare, as to their flora generally, the Atlantic United States with Japan, Mandchuria, and Northern China,—*i.e.*, Eastern North America with Eastern North Asia, half the earth's circumference apart,—we find an astonishing similarity. The larger part of the genera of our own region, which I have enumerated as wanting in California, are present in Japan or Mandchuria, along with many other peculiar plants, divided between the two. There are plants enough of the one region which have no representatives in the other. There are types which appear to have reached the Atlantic States from the south; and there is a larger infusion of subtropical Asiatic types into temperate China and Japan; among these there is no relationship between the two countries to speak of. There are also, as I have already said, no small number of genera and some species which, being common all round or partly round the northern temperate zone, have no special significance because of their occurrence in these two antipodal floras, although they have testimony to bear upon the general question of geographical distribution. The point to be remarked is, that many, or even most, of the genera and species which are pe-

culiar to North America as compared with Europe, and largely peculiar to Atlantic North America as compared with the Californian region, are also represented in Japan and Mandchuria, either by identical or by closely similar forms! The same rule holds on a more northward line, although not so strikingly. If we compare the plants, say of New England and Pennsylvania (lat. 45°–47°), with those of Oregon, and then with those of North-Eastern Asia, we shall find many of our own curiously repeated in the latter, while only a small number of them can be traced along the route even so far as the western slope of the Rocky Mountains. And these repetitions of East American types in Japan and neighboring districts are in all degrees of likeness. Sometimes the one is undistinguishable from the other; sometimes there is a difference of aspect, but hardly of tangible character; sometimes the two would be termed marked varieties if they grew naturally in the same forest or in the same region; sometimes they are what the botanist calls representative species, the one answering closely to the other, but with some differences regarded as specific; sometimes the two are merely of the same genus, or not quite that, but of a single or very few species in each country; when the point which interests us is, that this peculiar limited type should occur in two antipodal places, and nowhere else.

It would be tedious, and, except to botanists, abstruse, to enumerate instances; yet the whole strength of the case depends upon the number of such instances. I propose therefore, if the Association does me the honor to print this discourse, to append in a note a list of the more remarkable ones.* But I would here mention certain cases as specimens.

Our Rhus Toxicodendron, or Poison Ivy, is very exactly repeated in Japan, but is found in no other part of the world, although a species much like it abounds in California. Our other poisonous Rhus (R. venenata), commonly called Poison Dogwood, is in no way represented in Western America, but has so close an analogue in Japan that the two were taken for the same by Thunberg and Linnæus, who called them both R. Vernix.

Our northern Fox-grape, Vitis Labrusca, is wholly confined to the Atlantic States, except that it reappears in Japan and that region.

The original Wistaria is a woody leguminous climber with

* See Appendix, I.

showy blossoms, native to the middle Atlantic States; the other species, which we so much prize in cultivation, W. Sinensis, is from China, as its name denotes, or perhaps only from Japan, where it is certainly indigenous.

Our Yellow-wood (Cladrastis) inhabits a very limited district on the western slope of the Alleghanies. Its only and very near relative, Maackia, is in Mandchuria.

The Hydrangeas have some species in our Alleghany region: all the rest belong to the Chino-Japanese region and its continuation westward. The same may be said of Philadelphus, except that there are one or two mostly very similar species in California and Oregon.

Our Blue Cohosh (Caulophyllum) is confined to the woods of the Atlantic States, but has lately been discovered in Japan.* A peculiar relative of it, Diphylleia, confined to the higher Alleghanies, is also repeated in Japan, with a slight difference, so that it may barely be distinguished as another species. Another relative is our Twin-leaf (Jeffersonia) of the Alleghany region alone: a second species has lately turned up in Mandchuria. A relative of this is Podophyllum, our Mandrake, a common inhabitant of the Atlantic United States, but found nowhere else. There is one other species of it, and that is in the Himalayas. Here are four most peculiar genera of one family, each of a single species in the Atlantic United States, which are duplicated on the other side of the world, either in identical or almost identical species, or in an analogous species, while nothing else of the kind is known in any other part of the world.

I ought not to omit Ginseng, the root so prized by the Chinese, which they obtained from their northern provinces and Mandchuria, and which is now known to inhabit Corea and Northern Japan. The Jesuit Fathers identified the plant in Canada and the Atlantic States, brought over the Chinese name by which we know it, and established the trade in it, which was for many years most profitable. The exportation of Ginseng to China probably has not yet entirely ceased. Whether the Asiatic and the Atlantic American Ginsengs are to be regarded as of the same species or not is somewhat uncertain, but they are hardly, if at all, distinguishable.

There is a shrub, Elliottia, which is so rare and local that it is

* Appendix, II.

known only at two stations on the Savannah River, in Georgia. It is of peculiar structure, and was without near relative until one was lately discovered in Japan (Tripetaleia), so like it as hardly to be distinguishable except by having the parts of the blossom in threes instead of fours, — a difference which is not uncommon in the same genus, or even in the same species.

Suppose Elliottia had happened to be collected only once, a good while ago, and all knowledge of the limited and obscure locality were lost; and meanwhile the Japanese form came to be known. Such a case would be parallel with an actual one. A specimen of a peculiar plant (Shortia galacifolia) was detected in the herbarium of the elder Michaux, who collected it (as his autograph ticket shows) somewhere in the high Alleghany Mountains, more than eighty years ago. No one has seen the living plant since or knows where to find it, if haply it still flourishes in some secluded spot. At length it is found in Japan; and I had the satisfaction of making the identification.* One other relative is also known in Japan; and another, still unpublished, has just been detected in Thibet.

Whether the Japanese and the Alleghanian plants are exactly the same or not, it needs complete specimens of the two to settle. So far as we know, they are just alike; and even if some difference were discerned between them, it would not appreciably alter the question as to how such a result came to pass. Each and every one of the analogous cases I have been detailing — and very many more could be mentioned — raises the same question, and would be satisfied with the same answer.

These singular relations attracted my curiosity early in the course of my botanical studies, when comparatively few of them were known, and my serious attention in later years, when I had numerous and new Japanese plants to study in the collections made, by Messrs. Williams and Morrow, during Commodore Perry's visit in 1853, and especially, by Mr. Charles Wright, in Commodore Rodgers's expedition in 1855. I then discussed this subject somewhat fully, and tabulated the facts within my reach.†

This was before Heer had developed the rich fossil botany of the arctic zone, before the immense antiquity of existing species of plants was recognized, and before the publication of Darwin's now famous volume on the "Origin of Species" had introduced

* Amer. Jour. Science, 1867, p. 402; Proceed. Amer. Acad., viii. p. 244.

† Mem. Amer. Acad., vol. vi. pp. 377–458 (1859).

and familiarized the scientific world with those now current ideas respecting the history and vicissitudes of species with which I attempted to deal in a moderate and feeble way.

My speculation was based upon the former glaciation of the northern temperate zone, and the inference of a warmer period preceding and perhaps following. I considered that our own present vegetation, or its proximate ancestry, must have occupied the arctic and subarctic regions in pliocene times, and that it had been gradually pushed southward as the temperature lowered and the glaciation advanced, even beyond its present habitation; that plants of the same stock and kindred, probably ranging round the arctic zone as the present arctic species do, made their forced migration southward upon widely different longitudes, and receded more or less as the climate grew warmer; that the general difference of climate which marks the eastern and the western sides of the continents — the one extreme, the other mean — was doubtless even then established, so that the same species and the same sorts of species would be likely to secure and retain foothold in the similar climates of Japan and the Atlantic United States, but not in intermediate regions of different distribution of heat and moisture; so that different species of the same genus, as in Torreya, or different genera of the same group, as Redwood, Taxodium, and Glyptostròbus, or different associations of forest trees, might establish themselves each in the region best suited to the particular requirements, while they would fail to do so in any other. These views implied that the sources of our actual vegetation and the explanation of these peculiarities were to be sought in, and presupposed, an ancestry in pliocene or still earlier times, occupying the higher northern regions. And it was thought that the occurrence of peculiarly North American genera in Europe in the tertiary period (such as Taxodium, Carya, Liquidambar, Sassafras, Negundo, &c.) might be best explained on the assumption of early interchange and diffusion through North Asia, rather than by that of the fabled Atlantis.

The hypothesis supposed a gradual modification of species in different directions under altering conditions, at least to the extent of producing varieties, sub-species, and representative species, as they may be variously regarded; likewise the single and local origination of each type, which is now almost universally taken for granted.

The remarkable facts in regard to the Eastern American and

Asiatic floras which these speculations were to explain have since increased in number, more especially through the admirable collections of Dr. Maximowicz in Japan and adjacent countries, and the critical comparisons he has made and is still engaged upon.

I am bound to state that, in a recent general work* by a distinguished European botanist, Professor Grisebach, of Göttingen, these facts have been emptied of all special significance, and the relations between the Japanese and the Atlantic United States flora declared to be no more intimate than might be expected from the situation, climate, and present opportunity of interchange. This extraordinary conclusion is reached by regarding as distinct species all the plants common to both countries between which any differences have been discerned, although such differences would probably count for little if the two inhabited the same country, thus transferring many of my list of identical to that of representative species; and then by simply eliminating from consideration the whole array of representative species, *i.e.*, all cases in which the Japanese and the American plant are not exactly alike. As if, by pronouncing the cabalistic word *species*, the question were settled, or rather the greater part of it remanded out of the domain of science; as if, while complete identity of forms implied community of origin, any thing short of it carried no presumption of the kind; so leaving all these singular duplicates to be wondered at, indeed, but wholly beyond the reach of inquiry.†

Now the only known cause of such likeness is inheritance; and as all transmission of likeness is with some difference in individuals, and as changed conditions have resulted, as is well known, in very considerable differences, it seems to me that, if the high antiquity of our actual vegetation could be rendered probable, not to say certain, and the former habitation of any of our species or of very near relatives of them in high northern regions could be ascertained, my whole case would be made out. The needful facts, of which I was ignorant when my essay was published, have now been for some years made known, — thanks, mainly, to the researches of Heer upon ample collections of arctic fossil plants. These are confirmed and extended by new investigations, by Heer and Lesquereux, the results of which have been indicated to me by the latter.‡

* Die Vegetation der Erde nach ihrer klimatischen Anordnung. 1871.

† See Appendix II.

‡ Reference should also be made to the extensive researches of Newberry

The Taxodium, which everywhere abounds in the miocene formations in Europe, has been specifically identified, first by Gœppert, then by Heer, with our common Cypress of the Southern States. It has been found fossil in Spitzbergen, Greenland, and Alaska, — in the latter country along with the remains of another form, distinguishable, but very like the common species; and this has been identified by Lesquereux in the miocene of the Rocky Mountains. So there is one species of tree which has come down essentially unchanged from the tertiary period, which for a long while inhabited both Europe and North America, and also, at some part of the period, the region which geographically connects the two (once doubtless much more closely than now), but which has survived only in the Atlantic United States and Mexico.

The same Sequoia which abounds in the same miocene formations in Northern Europe has been abundantly found in those of Iceland, Spitzbergen, Greenland, Mackenzie River, and Alaska. It is named S. Langsdorfii, but is pronounced to be very much like S. sempervirens, our living Redwood of the Californian coast, and to be the ancient representative of it. Fossil specimens of a similar, if not the same, species have recently been detected in the Rocky Mountains by Hayden, and determined by our eminent palæontological botanist, Lesquereux; and he assures me that he has the common Redwood itself from Oregon in a deposit of tertiary age. Another Sequoia (S. Sternbergii), discovered in miocene deposits in Greenland, is pronounced to be the representative of S. gigantea, the big tree of the Californian Sierra. If the Taxodium of the tertiary time in Europe and throughout the arctic regions is the ancestor of our present Bald Cypress, — which is assumed in regarding them as specifically identical, — then I think we may, with our present light, fairly assume that the two Redwoods of California are the direct or collateral descendants of the two ancient species which so closely resemble them.

upon the tertiary and cretaceous floras of the Western United States. See especially Professor Newberry's Paper in the "Boston Journal of Natural History," vol. vii. No. 4, describing fossil plants of Vancouver's Island, &c.; his Notes on the Later Extinct Floras of North America, &c., in "Annals of the Lyceum of Natural History," vol. ix., April, 1868; "Report on the Cretaceous and Tertiary Plants collected in Raynolds and Hayden's Yellowstone and Missouri Exploring Expedition, 1859–1860," published in 1869; and an interesting article entitled "The Ancient Lakes of Western America, their Deposits and Drainage," published in "The American Naturalist," January, 1871.

The only document I was able to consult was Lesquereux's Report on the Fossil Plants, in Hayden's Report of 1872.

The forests of the arctic zone in tertiary times contained at least three other species of Sequoia, as determined by their remains, one of which, from Spitzbergen, also much resembles the common Redwood of California. Another, "which appears to have been the commonest coniferous tree on Disco," was common in England and some other parts of Europe. So the Sequoias, now remarkable for their restricted station and numbers, as well as for their extraordinary size, are of an ancient stock: their ancestors and kindred formed a large part of the forests which flourished throughout the polar regions, now desolate and ice-clad, and which extended into low latitudes in Europe. On this continent one species, at least, had reached to the vicinity of its present habitat before the glaciation of the region. Among the fossil specimens already found in California, but which our trustworthy palæontological botanist has not yet had time to examine, we may expect to find evidence of the early arrival of these two Redwoods upon the ground which they now, after much vicissitude, scantily occupy.

Differences of climate, or circumstances of migration, or both, must have determined the survival of Sequoia upon the Pacific, and of Taxodium upon the Atlantic coast. And still the Redwoods will not stand in the east, nor could our Taxodium find a congenial station in California. Both have probably had their opportunity in the olden time, and failed.

As to the remaining near relative of Sequoia, the Chinese Glyptostrobus, a species of it, and its veritable representative, was contemporaneous with Sequoia and Taxodium, not only in temperate Europe, but throughout the arctic regions from Greenland to Alaska. According to Newberry, it was abundantly represented in the miocene flora of the temperate zone of our own continent, from Nebraska to the Pacific.

Very similar would seem to have been the fate of a more familiar gymnospermous tree, the Gingko or Salisburia. It is now indigenous to Japan only. Its ancestor, as we may fairly call it,—since, according to Heer, "it corresponds so entirely with the living species that it can scarcely be separated from it," — once inhabited Northern Europe, and the whole arctic region round to Alaska, and had even a representative farther south, in our Rocky Mountain district. For some reason, this and Glyptostrobus survive only on the shores of Eastern Asia.

Libocedrus, on the other hand, appears to have cast in its lot

with the Sequoias. Two species, according to Heer, were with them in Spitzbergen. L. decurrens, the Incense Cedar, is one of the noblest associates of the present Redwoods. But all the rest are in the southern hemisphere, two at the southern extremity of the Andes, two in the South Sea Islands. It is only by bold and far-reaching suppositions that they can be geographically associated.

The genealogy of the Torreyas is still wholly obscure; yet it is not unlikely that the yew-like trees, named Taxites, which flourished with the Sequoias in the tertiary arctic forests, are the remote ancestors of the three species of Torreya, now severally in Florida, in California, and in Japan.

As to the Pines and Firs, these were more numerously associated with the ancient Sequoias of the polar forests than with their present representatives, but in different species, apparently more like those of Eastern than of Western North America. They must have encircled the polar zone then, as they encircle the present temperate zone now.

I must refrain from all enumeration of the angiospermous or ordinary deciduous trees and shrubs, which are now known, by their fossil remains, to have flourished throughout the polar regions when Greenland better deserved its name and enjoyed the present climate of New England and New Jersey. Then Greenland and the rest of the north abounded with Oaks, representing the several groups of species which now inhabit both our eastern and western forest districts; several Poplars, one very like our Balsam Poplar, or Balm of Gilead tree; more Beeches than there are now, a Hornbeam, and a Hop-Hornbeam, some Birches, a Persimmon, and a Planer-tree, near representatives of those of the Old World, at least of Asia, as well as of Atlantic North America, but all wanting in California; one Juglans like the Walnut of the Old World, and another like our Black Walnut; two or three Grape-vines, one near our Southern Fox Grape or Muscadine, another near our Northern Frost Grape; a Tilia, very like our Basswood of the Atlantic States only; a Liquidambar; a Magnolia, which recalls our M. grandiflora; a Liriodendron, sole representative of our Tulip-tree; and a Sassafras, very like the living tree.

Most of these, it will be noticed, have their nearest or their only living representatives in the Atlantic States, and when elsewhere, mainly in Eastern Asia. Several of them, or of species like them, have been detected in our tertiary deposits, west of the Missis-

sippi, by Newberry and Lesquereux. Herbaceous plants, as it happens, are rarely preserved in a fossil state, else they would probably supply additional testimony to the antiquity of our existing vegetation, its wide diffusion over the northern and now frigid zone, and its enforced migration under changes of climate.*

Concluding, then, as we must, that our existing vegetation is a continuation of that of the tertiary period, may we suppose that it absolutely originated then? Evidently not.. The preceding cretaceous period has furnished to Carruthers in Europe a fossil fruit like that of the Sequoia gigantea of the famous groves, associated with Pines of the same character as those that accompany the present tree; has furnished to Heer, from Greenland, two more Sequoias, one of them identical with a tertiary species, and one nearly allied to Sequoia Langsdorfii, which in turn is a probable ancestor of the common Californian Redwood; has furnished to Newberry and Lesquereux in North America the remains of another ancient Sequoia, a Glyptostrobus, a Liquidambar which well represents our Sweet-gum-tree, Oaks analogous to living ones, leaves of a Plane-tree, which are also in the tertiary and are scarcely distinguishable from our own Platanus occidentalis, of a Magnolia and a Tulip-tree, and "of a Sassafras undistinguishable from our living species." I need not continue the enumeration. Suffice it to say that the facts justify the conclusion which Lesquereux — a scrupulous investigator — has already announced: "that the essential types of our actual flora are marked in the cretaceous period, and have come to us after passing, without notable changes, through the tertiary formations of our continent."

According to these views, as regards plants at least, the adaptation to successive times and changed conditions has been maintained, not by absolute renewals, but by gradual modifications. I, for one, cannot doubt that the present existing species are the lineal successors of those that garnished the earth in the old time

* There is, at least, one instance so opportune to the present argument that it should not pass unnoticed, although I had overlooked the record until now. Onoclea sensibilis is a Fern peculiar to the Atlantic United States (where it is common and wide-spread) and to Japan. Professor Newberry identified it several years ago in a collection obtained by Dr. Hayden of miocene fossil plants of Dacotah Territory, which is far beyond its present habitat. He moreover regards it as probably identical with a fossil specimen "described by the late Professor E. Forbes, under the name of Filicites Hebridicus, and obtained by the Duke of Argyll from the Island of Mull."

before them, and that they were as well adapted to their surroundings then, as those which flourish and bloom around us are to their conditions now. Order and exquisite adaptation did not wait for man's coming, nor were they ever stereotyped. Organic nature, — by which I mean the system and totality of living things, and their adaptation to each other and to the world, — with all its apparent and indeed real stability, should be likened, not to the ocean, which varies only by tidal oscillations from a fixed level to which it is always returning, but rather to a river, so vast that we can neither discern its shores nor reach its sources, whose onward flow is not less actual because too slow to be observed by the *ephemeræ* which hover over its surface, or are borne upon its bosom.

Such ideas as these, though still repugnant to some, and not long since to many, have so possessed the minds of the naturalists of the present day, that hardly a discourse can be pronounced or an investigation prosecuted without reference to them. I suppose that the views here taken are little, if at all, in advance of the average scientific mind of the day. I cannot regard them as less noble than those which they are succeeding.

An able philosophical writer, Miss Frances Power Cobbe, has recently and truthfully said:*

> "It is a singular fact, that when we can find out how any thing is done, our first conclusion seems to be that God did not do it. No matter how wonderful, how beautiful, how intimately complex and delicate has been the machinery which has worked, perhaps for centuries, perhaps for millions of ages, to bring about some beneficent result, if we can but catch a glimpse of the wheels its divine character disappears."

I agree with the writer that this first conclusion is premature and unworthy,—I will add, deplorable. Through what faults or infirmities of dogmatism on the one hand, and scepticism on the other, it came to be so thought, we need not here consider. Let us hope, and I confidently expect, that it is not to last; that the religious faith which survived without a shock the notion of the fixity of the earth itself may equally outlast the notion of the absolute fixity of the species which inhabit it; that, in the future even more than in the past, faith in an *order*, which is the basis of science, will not — as it cannot reasonably — be dissevered from faith in an *Ordainer*, which is the basis of religion.

* Darwinism in Morals, in Theological Review, April, 1871.

APPENDIX.

I.

In the following table the names in the left-hand column are from my "Manual of the Botany of the Northern United States," and from Dr. Chapman's "Flora of the Southern United States," the two together comprehending the flora of the Atlantic United States east of the Mississippi River. Alpine plants on the one hand, and subtropical plants on the other, are excluded.

The entries in the middle column, when there are any, are of identical or representative species occurring in Oregon or California.

Those in the right-hand column are of such species in Japan, or other parts of North-Eastern Asia, including the Himalayas and Siberia as far west as the Altai Mountains.

When these are not identical, or so closely related to the American species that the one may be said strictly to represent the other, also when genera or parts of genera are adduced merely as representing the same type in these respective regions, the names are included in parentheses.

Species which extend through Europe into North-Eastern Asia, and therefore nearly round the temperate zone, are also left out of view, the object being to exhibit the *peculiar* relations of the floras of Eastern North America and Eastern Temperate Asia. The table has been drawn up offhand, from the means within reach. Probably the examples might be considerably increased.

Extra-European (Temperate) Genera and Species of the Atlantic United States (*i.e.*, East of the Mississippi) represented by Identical or strictly Representative Species, or else by less intimately related Species (the latter included in Parentheses),

	1. *In the Pacific United States.*	2. *In North-Eastern Asia, Japan to Altai and the Himalayas.*
Anemone Pennsylvanica.		Anemone dichotoma = Pennsylvanica.
,, parviflora.		,, parviflora ?
Ranunculus alismæfolius.	Ranunculus alismæfolius.	Ranunculus alismæfolius.
,, Cymbalaria.	,, Cymbalaria.	,, Cymbalaria.
,, Gmelini.	,, Gmelini.	,, Gmelini.
,, Pennsylvanicus.	,, Pennsylvanicus	,, Pennsylvanicus.
Trautvetteria palmata.	Trautvettaria palmata.	Trautvettaria palmata.
Hydrastis Canadensis.		Hydrastis Jesoensis. [Ledeb.
Trollius Americanus.	Trollius Americanus var.	Trollius patulus var. = Americanus,
Aconitum uncinatum.		Aconitum uncinatum ex Hook. f.
Actæa spicata, var. rubra.	Actæa spicata, var. arguta.	Actæa spicata, var. rubra.
,, alba.		,, alba ?
Cimicifuga Americana.		Cimicifuga fœtida, barely occurs in N. Europe also.

Cimicifuga racemosa & cordifolia.	(Cimicifuga elata.)	(Cimicifuga Dahurica and § Pityrosperma, 8 spp.)
Illicium Floridanum & parviflorum		Illicium anisatum, religiosum, &c.
Schizandra coccinea.		(Schizandra nigra, &c.)
Magnolia, 7 spp.		(Magnolia, 8–12 spp.)
Menispermum Canadense.		Menispermum Dahuricum.
Caulophyllum thalictroides.*		Caulophyllum thalictroides.
Diphylleia cymosa.		Diphylleia Grayi.
Jeffersonia diphylla.		Jeffersonia = Plagiorhegma dubium.
Podophyllum peltatum.		(Podophyllum Emodi.)
Brasenia peltata.	Brasenia peltata.	Brasenia peltata.
Nelumbium luteum.		Nelumbium speciosum.
Stylophorum diphyllum.		(Stylophorum Japonicum and lactucoides.)
Dicentra eximia.	Dicentra eximia or formosa	(Dicentra spp.)
Corydalis aurea.	Corydalis aurea var.	Corydalis aurea var., &c.
Viola Selkirkii.		Viola Selkirkii.
„ Canadensis.	Viola Canadensis var.	„ Canadensis var.
Claytonia Virginica & Caroliniana.	Claytonia lanceolata.	(Claytonia spp., Siberia.)
Elodes Virginica.		Elodes Virginica.
„ petiolata.		„ petiolata.
Tilia Americana (American type).		Tilia sp., American type, one of which reaches Hungary.
„ heterophylla.		
Stuartia, 2 spp.		(Stuartia, 3 spp.)
Xanthoxylum spp.		(Xanthoxylum spp.)
Rhus venenata.		Rhus vernicifera, &c.
„ Toxicodendron.	Rhus diversiloba.	„ Toxicodendron.
Vitis Labrusca.		Vitis Labrusca.
„ indivisa.		„ humulifolia.
Ampelopsis quinquefolia.		(Ampelopsis tricuspidata.)
Berchemia volubilis.		(Berchemia racemosa, &c.)
Sageretia Michauxii.		(Sageretia theæsans.)
Celastrus scandens.		(Celastrus, 5 spp.)
Æsculus glabra.		Æsculus Chinensis & Hippocastanum.
„ flava and Pavia.		(„ dissimilis.)
„ parviflora.	(Æsculus Californica.)	(„ Punduana Wall.)
Acer spicatum.		„ spicatum var.
„ Pennsylvanicum.		„ tegmentosum.
Negundo aceroides.	Negundo aceroides Californicum.	(Negundo cissifolium and spp.)
Wistaria frutescens.		Wistaria Sinensis and spp.
Desmodium, many spp.		(Desmodium, several spp.)
Lespedeza spp.		(Lespedeza spp.)
Rhynchosia spp.		(Rhynchosia sp.)
Amphicarpæa monoica.		(Amphicarpæa, 5 spp.)
Thermopsis, 3 spp.	(Thermopsis fabacea & sp.)	Thermopsis fabacea.
Cladrastis tinctoria.		(Maackia Amurensis.)
Cassia spp.		(Cassia spp.)
Gleditschia triacantha and monosperma.		Gleditschia Chinensis, &c.

* See Appendix, II.

Neptunia lutea.		(Neptunia spp.)
Spiræa (Neillia) opulifolia.	Spiræa opulifolia.	(Neillia spp., Himalayas.)
„ corymbosa.	„ betulæfolia.	Spiræa betulæfolia.
Neviusa Alabamensis.		(Stephanandra, Kerria.)
Geum macrophyllum.	Geum macrophyllum.	Geum Japonicum.
Potentilla Pennsylvanica.	Potentilla Pennsylvanica.	Potentilla Pennsylvanica.
Rubus triflorus.		Rubus triflorus, var. Japonicus.
„ strigosus.	Rubus strigosus.	„ strigosus.
Pyrus Americana and sambucifolia.	Pyrus sambucifolia.	Pyrus Americana and sambucifolia.
Amelanchier Canadensis and vars.	Amelanchier Canadensis var.	Amelanchier Canadensis var.
Calycanthus, 3 spp.	Calycanthus occidentalis.	(Chimonanthus fragrans.)
Ribes Cynosbati.	(Ribes spp.)	Ribes Cynosbati.
„ lacustre.	„ setosum.	„ lacustre.
„ prostratum.	„ laxiflorum.	„ laxiflorum.
Philadelphus, 2 spp.	Philadelphus, 2 spp.	Philadelphus spp.
Itea Virginica.		(Itea spp.)
Hydrangea, 3 spp.		(Hydrangea, many spp.)
Astilbe decandra.		Astilbe Thunbergii and spp.
Boykinia aconitifolia.	Boykinia occidentalis and elata.	(Boykinia ? = Saxifr. tellimioides Maxim.)
Mitella nuda.	Mitella nuda.	Mitella nuda, Siberia.
„ diphylla.	(Mitella § Mitellastra, &c., spp.)	(Mitella § Mitellastra, sp.)
Tiarella cordifolia.	Tiarella unifoliata.	Tiarella polyphylla.
Penthorum sedoides.		Penthorum sedoides ? = Chinense and humile.
Hamamelis Virginica.		Hamamelis Japonica, &c.
Fothergilla alnifolia.		(Corylopsis spp., &c.)
Heracleum lanatum.	Heracleum lanatum.	Heracleum lanatum.
Archangelica Gmelini.	Archangelica Gmelini.	Archangelica Gmelini.
Sium lineare.		Sium cicutæfolium.
Cryptotænia Canadensis.		Cryptotænia Canadensis.
Archemora, 2 spp.		(Peucedanum ? Sieboldii.)
Osmorrhiza longistylis and brevistylis.	Osmorrhiza longistylis, &c.	Osmorrhiza longistylis, &c.
Aralia spinosa.		Aralia spinosa var.
„ racemosa.	Aralia humilis.	„ edulis, &c.
„ nudicaulis.		(„ cordata.)
„ (Ginseng) quinquefolia.		„ repens, Ginseng, &c.
Cornus Canadensis.	Cornus Canadensis.	Cornus Canadensis.
„ florida.	„ Nuttallii.	Benthamia spp.
„ stolonifera		„ alba.
Diervilla, 2 spp.		(Diervilla § Weigela, spp.)
Triosteum, 2 spp.		Triosteum sinuatum and Himalaicum.
Viburnum lantanoides.		Viburnum lantanoides (and related species).
„ dentatum & pubescens.	Viburnum ellipticum.	„ dilatatum, &c.
Mitchella repens.		Mitchella undulata.
Adenocaulon bicolor.	Adenocaulon bicolor.	Adenocaulon adhærescens.

Cimicifuga racemosa & cordifolia.	(Cimicifuga elata
Illicium Floridanum & parviflorum	
Schizandra coccinea.	
Magnolia, 7 spp.	
Menispermum Canadense.	
Caulophyllum thalictroides.*	
Diphylleia cymosa.	
Jeffersonia diphylla.	
Podophyllum peltatum.	
Brasenia peltata.	Brasenia peltata
Nelumbium luteum.	
Stylophorum diphyllum.	
Dicentra eximia.	Dicentra eximia
Corydalis aurea.	Corydalis aurea
Viola Selkirkii.	
„ Canadensis.	Viola Canadensi
Claytonia Virginica & Caroliniana.	Claytonia lanceo
Elodes Virginica.	
„ petiolata.	
Tilia Americana (American type).	
„ heterophylla.	
Stuartia, 2 spp.	
Xanthoxylum spp.	
Rhus venenata.	
„ Toxicodendron.	Rhus diversiloba.
Vitis Labrusca.	
„ indivisa.	
Ampelopsis quinquefolia.	
Berchemia volubilis.	
Sageretia Michauxii.	
Celastrus scandens.	
Æsculus glabra.	
„ flava and Pavia.	
„ parviflora.	(Æsculus Californi
Acer spicatum.	
„ Pennsylvanicum.	
Negundo aceroides.	Negundo aceroides fornicum.
Wistaria frutescens.	
Desmodium, many spp.	
Lespedeza spp.	
Rhynchosia spp.	
Amphicarpæa monoica.	
Thermopsis, 3 spp.	(Thermopsis fabacea
Cladrastis tinctoria.	
Cassia spp.	
Gleditschia triacantha and monosperma.	

* See Appendix,

	Symplocos sp.
	[illegible]
	[illegible]
	Veronica Virginica.
	[illegible] sp.
	[illegible]
…pus Virginicus.	Lycopus [illegible]
	[illegible]
	Hedeoma sp.
…anthus spp.	[illegible] sp.
	[illegible] Scribneri.*
	[illegible] and spp.
…ox Douglasii and spp.	[illegible]
	[illegible]
	[illegible]
…cynum androsaemifolium.	Apocynum venetum.
	Amsonia elliptica.
…rum caudatum.	Asarum [illegible] and [illegible]
	— [illegible] and Sieboldii.
	Phytolacca Kaempferi, &c.
	Corispermum [illegible]
	Polygonum perfoliatum.
	— sagittatum and Sieboldii.
	Lindera triloba, &c.
	— hypoglauca, &c.
(…hranthera Californica.)	Tetranthera spp.
	(Pyrularia = Sphaerocarya spp.
	Saururus Loureiri.
	Schizandra spp.
	Pachysandra terminalis.
	Planera Japonica and Keaki.
	Maclura gerontogea.
	Pilea pumila.
	Laportea evitata, &c.
	Boehmeria spp.
	Parietaria debilis.
…ns rupestris.)	(Juglans regia.)

…noides: slender, branched from the base, stoloniferous? leaves …dentate, the lower round-cordate and slender-petioled, the others …d short-petioled, the floral similar but gradually smaller: flowers …h of the calyx; corolla (light purple?) only three lines long, its lips of nearly equal length: nutlets surrounded by an abrupt …disk muricate, the lower as if squamellate. *S. hederacea?* Gray, …trib. Proc. Amer. Acad. viii. p. 370, not of Kunth and Bouché. …72, p. 717, that S. hederacea is identical with the Tasmanian S. …ulate-tuberculate, and by implication wingless. So our …first collected a little of it at Simoda, Japan. Better …nds, by Charles Wright.

Boltonia spp.		(Boltonia spp.)
Aster § Biotia, corymbosus, & spp.		Aster § Biotia, corymbosus, and spp.
„ § Conyzopsis, angustus.	Aster angustus.	„ angustus = Brachyactis ciliata Ledeb.
Artemisia Canadensis.	Artemisia Canadensis.	Artemisia Canadensis ? = commutata.
„ biennis.	„ biennis.	„ biennis.
„ frigida.	„ frigida.	„ frigida.
Senecio pseudo-arnica.		Senecio pseudo-arnica.
Nabalus spp.		(Nabalus ochroleucus, acerifolius.)
Cacalia spp.		(Cacalia spp.)
Mulgedium pulchellum.	Mulgedium pulchellum.	Mulgedium Sibiricum.
Vaccinium § Oxycoccus macrocarpum.		Vaccinium macrocarpum, forma ambigua.*
„ „ erythrocarpum.		„ Japonicum (ab erythrocarpo vix differt.)
„ § Batodendron, 2 spp.		(„ § Batodendron, spp.)
„ § Cyanococcus, 15 spp.		(„ § Cyanococcus, one sp. near Pennsylvanicum.)
„ ovalifolium.	Vaccinum ovalifolium.	„ ovalifolium.
Chiogenes hispidula.		Chiogenes hispidula.
Epigæa repens.		Epigæa Asiatica.
Gaultheria procumbens.		Gaultheria pyroloides.
Leucothoe axillaris and Catesbæi.		Leucothoe Keiskei.
„ racemosa and recurva.		(„ Grayana and Tschonoskii.)
Andromeda § Portuna floribunda.		(Andromeda § Portuna sp.)
„ § Pieris spp.		(„ § Pieris spp.)
Clethra, 2 spp.		(Clethra sp.)
Menziesia ferruginea, var. globularis.	Menziesia globularis.	Menziesia pentandra and others.
Rhododendron Catawbiense.	Rhododendron Californicum.	(Rhododendron brachycarpon.)
„ maximum.		(„ Metternichii.)
„ punctatum.		(„ Keiskei.)
Rhodora Canadensis.		(„ spp.)
Azalea, 4 spp.	(Azalea occidentalis).	(Azalea spp.)
Elliottia racemosa.		Tripetaleia paniculata and bracteata.
Pyrola elliptica.		Pyrola elliptica.
Monotropa uniflora.		Monotropa uniflora.
Shortia galacifolia.		Shortia galacifolia = Schizocodon uniflorus.
Ilex § Prinos spp.		(Ilex § Prinos spp.)
Diospyros Virginiana.		(Diospyros spp.)

* "Ob flores revera terminales, bracteolas lineari-lanceolatas scariosas et folia acuta," Dr. Maximowicz (in Mel. Biolog. Diagn. decas 12) refers this to V. Oxycoccus, instead of to V. macrocarpum, which is "semper bene distinctum floribus axillaribus, bracteolis ovatis foliaceis et foliis obtusis." But in one of my specimens the axis of the umbel is continued into a leafy shoot, as in V. macrocarpum; and the bracteolæ vary from linear to ovate, and from thin and scarious to chartaceous or coriaceous in both species: they are never (so far as I know) "foliaceous" in V. macrocarpum, but the bracteæ sometimes are. The leaves are sometimes acutish in the latter, and also very obtuse in V. Oxycoccus; in the Japanese specimens under consideration they are often half an inch in length. I must add that in the length of the filaments they accord with the character which I assigned to V. Oxycoccus in the Manual. In fact, a form combining the characters of the two species survives in Japan.

Symplocos sp.		(Symplocos spp.)
Tecoma radicans.		Tecoma grandiflora.
Catalpa bignonioides.		Catalpa Kæmpferi.
Veronica Virginica.		Veronica Virginica.
Callicarpa Americana.		(Callicarpa, 8 spp.)
Phryma Leptostachya.		Phryma Leptostachya.
Lycopus Virginicus.	Lycopus Virginicus.	Lycopus parviflorus.
Teucrium Canadense.		Teucrium Japonicum.
Hedeoma, 4 spp.		(Hedeoma sp.)
Lophanthus spp.	Lophanthus spp.	(Lophanthus sp.)
Scutellaria (nuculis alatis) nervosa.		Scutellaria (nuculis alatis) Guilielmi.*
Halenia deflexa.		Halenia Sibirica, and spp.
Phlox subulata.	(Phlox Douglasii and spp.)	Phlox Sibirica.
Gelsemium sempervirens.		(Gelsemium elegans.)
Mitreola, 2 spp.		Mitreola oldenlandioides.
Apocynum androsæmifolium.	Apocynum androsæmifolium.	(Apocynum venetum.)
Amsonia Tabernæmontana.		(Amsonia elliptica.)
Asarum Virginicum & arifolium.	Asarum caudatum.	Asarum variegatum and Blumei.
„ Canadense.		„ caulescens and Sieboldii.
Phytolacca decandra.		Phytolacca Kæmpferi, &c.
Corispermum hyssopifolium.		Corispermum hyssopifolium.
Polygonum arifolium.		Polygonum perfoliatum.
„ sagittatum.		„ sagittatum and Sieboldii.
Sassafras officinale.		(Lindera triloba, &c.)
Lindera Benzoin, &c.		„ hypoglauca, &c.
Tetranthera geniculata.	(Tethranthera Californica.)	(Tetranthera spp.)
Pyrularia oleifera.		(Pyrularia = Sphærocarya spp.)
Saururus cernuus.		Saururus Loureiri.
Stillingia spp.		(Stillingia spp.)
Pachysandra procumbens.		Pachysandra terminalis.
Planera aquatica.		Planera Japonica (and Richardi).
Maclura aurantiaca.		Maclura gerontogæa.
Pilea pumila.		Pilea pumila.
Laportea Canadensis.		Laportea evitata, &c.
Bœhmeria cylindrica.		(Bœhmeria spp.)
Parietaria debilis.		Parietaria debilis.
Juglans nigra.	(Juglans rupestris.)	(Juglans regia.)

* SCUTELLARIA GUILIELMI n. sp. Perilomioides: slender, branched from the base, stoloniferous? leaves membranaceous, minutely pubescent, crenately dentate, the lower round-cordate and slender-petioled, the others ovate or oblong with rounded or truncate base and short-petioled, the floral similar but gradually smaller; flowers solitary in the axils; peduncles about the length of the calyx; corolla ("light purple," only three lines long) hardly more than twice the length of the calyx, its lips of nearly equal length; nutlets surrounded by an abrupt and reflexed denticulate wing, upper face of the disk muricate, the lower as if squamellate. *S. hederacea?* Gray, in Perry's Japan Exped. iii. p. 316, &. Bot. Contrib. Proc. Amer. Acad. viii. p. 370, not of Kunth and Bouché. It appears from a note by Vatke, in Bot. Zeit., 1872, p. 717, that S. hederacea is identical with the Tasmanian S. humils, and its nutlets were originally described as echinulate-tuberculate, and by implication wingless. So our plant may be named in honor of Dr. S. W. Williams, who first collected a little of it at Simoda, Japan. Better and fruiting specimens were gathered on the Loo-Choo Islands, by Charles Wright.

Juglans cinerea.		Juglans Mandchurica, stenocarpa.
Corylus rostrata.	Corylus rostrata var.	Corylus rostrata, var. Mandchurica.
Betula glandulosa.		Betula glandulosa.
„ nigra.		(„ ulmifolia, &c.)
Alnus maritima.		Alnus maritima.
Myrica cerifera.	Myrica Californica.	(Myrica Nagi.)
Pinus resinosa.		(Pinus densiflora, &c.)
„ Strobus.	Pinus monticola.	„ excelsa.
Abies Canadensis.	Abies Mertensiana.	Abies Tsuga and diversifolia.
Thuja occidentalis.	Thuja gigantea, &c.	Thuja Japonica.
Taxodium distichum.		(Glyptostrobus heterophyllus.)
Cupressus (Chamæcyparis) thuyoides.	C. Nutkæensis.	C. pisifera, obtusa, &c.
Taxus Canadensis.	Taxus brevifolia.	Taxus cuspidata.
Torreya taxifolia.	Torreya Californica.	Torreya nucifera and grandis.
Arisæma, 3 spp.		Arisæma, 9 spp.
Symplocarpus fœtidus.	(Lysichiton Camschatscense.)	Symplocarpus fœtidus ? and Lysichiton Camschatscense.
Listera australis.		(Listera Japonica, &c.)
Arethusa bulbosa.		(Arethusa Japonica.)
Pogonia ophioglossoides.		Pogonia ophioglossoides.
Microstylis ophioglossoides.		(Microstylis Japonica.)
Liparis liliifolia.		Liparis liliifolia ?
Cypripedium acaule.		(Cypripedium Japonicum.)
Habenaria virescens.		Habenaria fucescens.
Aletris farinosa and aurea.		Aletris Japonica.
Iris cristata.		Iris tectorum = cristata Miq.
Dioscorea villosa.		(Dioscorea spp.)
Smilax hispida.		Smilax Sieboldii.
„ herbacea and peduncularis.		„ herbacea = Nipponica.
„ tamnifolia.		(„ higoensis.)
Croomia pauciflora.		Croomia pauciflora.
Trillium grandiflorum.	Trillium obovatum.	Trillium obovatum.
„ erectum.		„ erectum var.
Tofieldia glutinosa and pubens.		(Tofieldia Japonica and nutans.)
Helonias bullata.		Heloniopsis pauciflora, breviscapa, Japonica.
Chamælirium luteum.		Chamælirium luteum.
Zygadenus, 3 spp.	Zygadenus glaucus, &c.	(Zygadenus Japonicus.)
Streptopus roseus.	Streptopus roseus.	Streptopus roseus.
Prosartes lanuginosa.	Prosartes Hookeri, &c.	Prosartes viridescens, &c.
Clintonia borealis.	Clintonia uniflora.	Clintonia Udensis.
Polygonatum giganteum.		Polygonatum giganteum.
Smilacina trifolia.		Smilacina trifolia.
„ racemosa.	Smilacina racemosa var.	„ Japonica.
„ stellata.	„ stellata.	„ Davarica.
Erythronium Americanum and albidum.	Erythronium grandiflorum.	Erythronium grandiflorum.
Narthecium Americanum.		Narthecium Asiaticum.
Scirpus Eriophorum.		Scirpus Eriophorum.
Carex rostrata.		Carex rostrata.

Carex stipata.	Carex stipata.	Carex stipata.
Zizania aquatica.		Zizania = Hydropyrum latifolium.
Arundinaria macrosperma.		(Arundinaria Japonica.)
Avena striata and Smithii.		Avena callosa.
Adiantum pedatum.	Adiantum pedatum.	Adiantum pedatum.
Pellæa gracilis.		Pellæa Stelleri = gracilis.
Aspidium fragrans.		Aspidium fragrans.
Asplenium thelypteroides.		Asplenium thelypteroides.
Camptosorus rhizophyllus.		Camptosorus Sibiricus.
Onoclea sensibilis.		Onoclea sensibilis.
Osmunda cinnamonea.		Osmunda cinnamonea.
„ Claytoniana.		„ Claytoniana.
Lygodium palmatum.		(Lygodium Japonicum.)
Botrychium Virginicum.		Botrychium Virginicum.
Lycopodium lucidulum.		Lycopodium lucidulum.
„ dendroideum.		„ dendroideum.

It appears that two-thirds of the middle column is blank; viz., that only a third of the species or forms which are more or less peculiar to Temperate Atlantic North America (*i.e.*, east of the Mississippi and south of the Great Lakes and the St. Lawrence) and to Temperate Eastern Asia, are represented in Oregon and California. Moreover, eighty of the genera here treated of are peculiar to North America and Temperate Asia: and sixty-three (*i.e.*, more than three-quarters) of these are not met with in Western North America.

This Table may be compared, or rather contrasted, with the following one.

EXTRA-EUROPEAN PLANTS OF TEMPERATE EASTERN ASIA WHICH ARE REPRESENTED IDENTICALLY OR BY SOME NEAR RELATIVE IN OREGON (SOUTH OF LAT. 48°) OR CALIFORNIA (ARCTIC-ALPINE PLANTS EXCLUDED), BUT NOT IN THE ATLANTIC UNITED STATES: —

Thalictrum sparsiflorum.	Thalictrum sparsiflorum.
Ranunculus affinis.	Ranunculis affinis.
Coptis occidentalis.	Coptis occidentalis.
„ brachypetala and Teeta.	„ asplenifolia.
Aconitum delphinifolium.	Aconitum delphinifolium.
Pœonia spp.	(Pœonia Rossii.)
Berberis § Mahonia spp.	(Berberis § Mahonia spp.)
Epimedium § Aceranthus sp.	(Vancouveria hexandra.)
Achlys Japonica.	Achlys triphylla.
Corydalis pæoniæfolia.	Corydalis pæoniæfolia.
Mœhringia umbrosa.	Mœhringia macrophylla.
Linum perenne.	Linum perenne.
Thermopsis fabacea.	Thermopsis fabacea.
Astragalus adsurgens.	Astragalus adsurgens.
Chamærhodos erecta.	Chamærhodos erecta.
Spiræa callosa.	Spiræa Nobleana.
Rubus spectabilis.	Rubus spectabilis.
Pyrus rivularis ?	Pyrus rivularis.
Cratægus sanguinea.	Cratægus Douglasii.
Rosa Kamtschatica.	Rosa Kamtschatica.
Photinia arbutifolia.	(Photinia serrulata.)
Saxifraga Sibirica.	Saxifraga Sibirica.
Mitella § Mitellaria spp.	(Mitella § Mitellaria spp.)
Glehnia littoralis.	Glehnia littoralis.
Oplopanax horrida.	Oplopanax horrida.
Echenais carlinoides.	Echinais carlinoides.
Lonicera Maximowiczii.	Lonicera Breweri.
Gaultheria adenothrix.	Gaultheria Myrsinites.
Rhododendron ovatum and semibarbatum.	Rhododendron albiflorum.
Pyrola subaphylla.	Pyrola aphylla.
Villarsia Crista-galli.	Villarsia Crista-galli.
Lycopus lucidus.	Lycopus lucidus.
Boschniakia glabra.	Boschniakia glabra.
Echinospermum patulum.	Echinospermum patulum.
„ Redowskii.	„ Redowskii.
Hottuynia cordata.	Anemiopsis Californica.
Quercus spp.	(Quercus densiflora.)
Castanopsis spp.	(Castanopsis chrysophylla.)
Lysichiton Camtschatcense.	Lysichiton Camtschatcense.
Erythronium grandiflorum.	Erythronium grandiflorum.
Carex macrocephala.	Carex macrocephala.
Triticum ægilopoides.	Triticum ægilopoides.
Elymus Sibiricus.	Elymus Sibiricus.
Abies Menziesii.	Abies Menziesii.
Woodwardia radicans.	Woodwardia radicans.

The entries are only forty-five; and the representation, when at all close, is by identical or nearly identical species. Only seven of the genera here noted are peculiar to North-Eastern Asia and North-Western America: viz., Glehnia, Oplopanax, and Lysichiton, each of a single species common to both coasts; Achlys, of which there is a Japanese species said to differ from the American; Boschniakia, of a common high northern species, and a peculiar one in California; Echinais, of one or two Asiatic species, one of them lately found in California and Colorado, but possibly of recent introduction; and Castanopsis, a rather large and characteristic East Asian genus, represented by a single but very distinct species in Oregon and California.

Small, under the circumstances, as is the number of cognate plants or forms in these two floras, it is large in comparison with those which are peculiar to the United States and Europe, excluding, as before, all Arctic-Alpine species. The following seem to be the principal: —

Anemone nemorosa, of which there is a peculiar Pacific form, perhaps reaching the eastern borders of Asia.

Myosorus minimus, which may be a recently introduced plant.

Cakile, a maritime genus.

Saxifraga aizoides.

Bellis integrifolia, which may be compared with the European B. annua.

Lobelia Dortmanna.

Primula Mistassinica.

Centunculus lanceolatus, a mere form of C. minimus.

Hottonia inflata, which represents H. palustris.

Utricularia minor.

Salicornia Virginica, the S. mucronata of Bigelow and probably of Lagasca also.

Corema Conradi, representing the Portuguese C. alba.

Vallisneria spiralis, which appears to be absent from Northern Asia.

Spiranthes Romanzoviana, with its single station on the Irish coast. It extends across the American continent well northward, but seemingly not into the adjacent parts of Asia.

Eriocaulon septangulare, restricted in the Old World to a few stations on West British coasts.

Carex extensa, C. flacca (or Barrattii), and one or two others.

Cinna arundinacea, var. pendula.

Leersia oryzoides.

Spartina stricta and S. juncea.

Equisetum Telmateia.

Lycopodium inundatum.

Calluna vulgaris, which holds as small and precarious a tenure on this continent as Spiranthes Romanzoviana does in Europe.

Barely two dozen; and three or four of these are more or less maritime. Only two or three of them extend west of the Mississippi Valley.

Narthecium is not in the list, a form or near ally of the European and Atlantic-American species having been detected in Japan: the genus is unknown on the Pacific side of our continent.

II.

SINCE the foregoing tables were prepared, a letter from Mr. Dall (who has returned from an arduous and successful exploration of the Alaskan region, made under the authority of the United States Coast Survey) informs me that his party met with Caulophyllum upon one of the Shumagin Islands. These islands lie off the southern shore of the peninsula of Alaska, about in latitude 55°, longitude 160°. No specimen occurs in the beautiful collection of dried plants made in this expedition, mainly by Mr. Harrington; nor indeed any other plants which affect so southern a range as our Caulophyllum. Yet the plant may well have been rightly identified; although it should be seen by botanists before any conclusions are drawn from it. But the occurrence of an intermediate station like this would probably lead Professor Grisebach to rank the North Asiatic Caulophyllum no longer as a *representative* species, but as identical with our Atlantic plant, as Miquel and Maximowicz, as well as myself, have already done upon evidence derived from the specimens.

Then,—upon Professor Grisebach's idea that, while identical species are to be referred to a single origin and the disseverance accounted for through means and causes now in operation, representative species have somehow arisen independently under similar climates,—Caulophyllum must be explained as a case of migration, but Diphylleia (in the same predicament, only with a perceptible difference between the two plants) as a case of double origination. So of the Shortia galacifolia and the Schizocodon uniflorus, of which the corolla and stamens in both are still wanting. If these, when found, should prove to be exactly alike in the two, the very difficult problem of accounting for the world-wide separation under present circumstances is to be encountered; if a difference appears, the problem is to consider how, and upon what, similar climates can have acted to have originated almost identical species upon opposite sides of the world. Professor Grisebach's views imply that "each species has arisen under the influence of physical and other external conditions," and that gradual alterations in a climate somehow produce adaptive "changes in organization;" wherefore, as the President of the Linnean Society has aptly remarked,*

* Address of George Bentham, Esq., President of the Linnæan Society, &c., read May 24, 1872.

"We have a right to ask of him, What is the previous organization upon which he imagines climate to have worked to produce allied species in one region and representative species in distant regions?" The difference here between Grisebach's conception and our own is, that we consider climate and other external conditions to have acted upon common ancestors in each case; but he apparently declines to conjecture what they acted upon.

In conclusion I may advert to one instance, in which it would appear, either that *widely different climates* have originated the same or closely similar species, or else that one and the same species (one of those common to the United States and Japan) has been dispersed over the globe in a manner and to an extent that place it beyond the reach of explanations limited to the results of forces still in activity and means of dispersion still available. Brasenia peltata inhabits, 1. The Atlantic United States, from Canada to Texas; 2. Oregon, or rather Washington Territory, a single known station at Gray's Harbor, on the Pacific, latitude 47°; and Clear Lake, in California, latitude 39°; 3. Japan; 4. Khasya and Bhotan, altitude 4–6000 feet; 5. Australia, Moreton Bay, &c.; 6. West Africa, in a lake in Angola!

PROCEEDINGS

OF THE

DUBUQUE MEETING, 1872.

COMMUNICATIONS.

A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

I. MATHEMATICS AND ASTRONOMY.

1. On Binary Stars. By Daniel Kirkwood, of Bloomington, Indiana.

At the meeting of the Royal Astronomical Society on the 10th of May, 1872, it was announced by Mr. Wilson that a discussion of all the observations of the double star Castor, from 1719 to the present time, had led to the remarkable conclusion that the components are moving in hyperbolas, and consequently that their mutual relation as members of a system is but temporary. The fact, if confirmed, will be regarded with great interest; and its discovery will doubtless be followed by a minute and vigilant scrutiny of other binary systems.

But while such a relation as that discovered by Mr. Wilson had not been previously suspected, its existence was certainly not altogether improbable. As the sun in his progressive motion through space compels such cometary matter as may come within the sphere of his influence to move about him in parabolas or hyperbolas, so two bodies of the same order of magnitude may be brought by their proper motions within such proximity that their mutual attraction shall cause each to move about the other in a hyperbolic orbit. Such instances, however, would seem to be ex-

ceptions to the general rule; as the motion of most binary stars is undoubtedly elliptic.*

The components of Castor are of the magnitudes 3 and 3½ respectively. If we suppose that each, before the epoch of their physical connection, was the centre of a planetary system, the results of perturbation must have been extremely disastrous. The two stars were at their least distance from each other in 1858.

This alleged discovery of a temporary physical connection between two fixed stars suggests a number of interesting inquiries. In the infinitely varied and complicated movements of the sidereal systems different bodies may be brought into such juxtaposition as to change, not only the direction of their motions, but also the orbits of their dependent planets. Some stars, at the rate of motion indicated by the spectroscope, would pass over an interval equal to that which separates us from the nearest neighboring systems in 20,000 years. In view of these facts, the conjecture of Poisson, that the temperature of the earth's surface at different epochs has depended upon the high or low temperature of the portions of space through which the solar system has passed, may not be wholly improbable.

A possible origin of binary systems is also indicated by Mr. Wilson's discovery. The cometary eccentricity of the orbits of these bodies is well known. In some cases the estimated distance between the components at the time of their periastral passage is less than half the radius of the earth's orbit. Now, if at the epoch of the first nearest approach the radius of either star's nebulous envelope was greater than the distance between the centres of the two bodies, the atmospheric resistance would tend to transform the parabola or hyperbola, in which the body was moving, into an ellipse. Each subsequent return would shorten the period until, in the process of cooling, the stellar atmosphere had so far contracted as no longer to involve any part of its companion's orbit.

It would be an interesting question whether some of the double stars, whose apparent distance apart has seemed too great to justify the hypothesis of a physical connection, may not afford other instances of motion either in parabolas or hyperbolas.

* In the American Journal of Science and Arts, for March, 1864, the writer called attention to the great eccentricity of the orbits of binary stars, and attempted an explanation of the fact in accordance with the nebular hypothesis.

II. PHYSICS AND CHEMISTRY.

1. Apparatus for Electric Measurement, with Rules and Directions for its Practical Application. By L. Bradley, of Jersey City, N.J.

It is about eight years since the writer of this paper undertook the work of constructing an instrument for the measurement of resistances, intended to be used daily in regular business, as the grocer uses his scale-beam. The result, though rude and imperfect, was still valuable; for it enabled him approximately to determine the resistances of all helices and electro-magnets manufactured and put upon the market by him.

The measurement of resistance was all that was then aspired to, and the apparatus received the name of *Anthistometer*, a Greek derivative, signifying "a measure of resistance."

From that to the present time, he has endeavored, by indefatigable exertion and thought, to keep pace with the progress so rapidly making in electrical science, and especially in that of electric measurement generally.

Instead of a rude and imperfect measure of resistance, he now presents an apparatus so largely improved, and so well defined in its applications and capacities, that electricians in all departments find every desirable means for absolute and correct measurement, put up in a substantial, compact, cheap, and portable form.

By this, telegraph companies may directly measure the resistance of their lines; also their insulation resistance up to millions of ohms. They may locate breaks, faults, and crosses, when they occur; and they may determine the resistance, strength, and electro-motive force of their batteries.

Metallurgists, engaged in electrolysis, may determine the quantity of metal of any kind deposed by a current in a given time with great accuracy; a desideratum to those engaged in electrotyping, gilding, &c.

Wire manufacturers may readily determine the quality of the metal they are working up; the specific resistance and conductivity of the wire put upon the market, compared with that of pure

copper, — a matter of great importance to those purchasing for telegraphic or other electrical purposes.

In short, the capacities of all other instruments combined for similar purposes are embraced in this one, in a form so compact and substantial as to be exceedingly convenient, and comparatively safe from injury by use or from rough handling.

The apparatus consists of his *Tangent Galvanometer* and his *Rheostat* as they have been recently improved.

The Tangent Galvanometer, of most recent construction, is composed of a compass dial, five or six inches in diameter, having a fine steel point in the centre, which supports a needle of a form peculiar to this invention. Underneath these are placed coils of several capacities, designed to measure various currents, from those of great intensity with but little quantity to those of great quantity with but little intensity.

The needle is composed of a thin circular plate of tempered steel, in the centre of which is fixed an aluminium cup containing an agate to rest upon the point at the centre of the compass, or it may be made of three or more oblong plates, riveted upon a flat ring of aluminium, so trimmed as to form a perfectly circular disk. From the meridian of the disk long, slender aluminium pointers extend to denote the degrees of deflection. The needle being properly polarized, and placed upon the point, obeys every electrical impulse with great celerity. Its weight is scarcely twenty grains, and in some cases not even half that.

The coils are so placed that the current runs parallel with the meridian of the needle. They are half an inch or more wider than the diameter of the disk. By this means all parts of the steel composing the needle are subjected to the same inductive influence in all its deflections.

It is a condition indispensable in the construction of a true Tangent Galvanometer, that the current through the coil should act as uniformly upon the needle in all its deflections as the earth's magnetism does: a narrow coil under a long needle does not fulfil this condition; for, as the extremities of the needle in its deflections pass more and more away from the coil, the inductive influence is less and less, as compared with the earth's influence.

On the contrary, if we place a very broad coil under a long needle, the same difficulty occurs, but in the opposite direction. While the needle is on the meridian it is under the influence of but few convolutions in the middle of the coil, but as it is deflected it

comes under the influence of an increasing number of convolutions, and therefore the influence is more and more increased.

It being evident that the truth lay between these extremes, the expedient of a needle in the form above described was resorted to, and with entire success, for in this the condition sought is accurately fulfilled.

Coil No. 1 is composed of very fine copper wire, wound evenly back and forth over the whole width of the coil, and of a sufficient number of layers to give a resistance of 150 or more ohms.

No. 2 is of No. 30 wire wound in the same manner, and to 25 or 30 ohms resistance. No. 3 is of two layers of No. 23 wire, giving from one to two ohms resistance. And No. 4 is a strip of sheet copper of the width of the coils, and wound three and a half times round, so that the current passes four times under the needle: the resistance of this may be considered as null, or not sufficient to be noticed or taken into account.

The outer ends of all the coils are connected with a common screw-cup, while the inner ones are connected each with a cup bearing its proper number.

One, two, or even three of the coils may be dispensed with in galvanometers for special purposes, according to the function to be performed.

Coil No. 1 is for currents of high intensity, No. 4 for those of great quantity, and Nos. 2 and 3 are for mixed or intermediate currents.

Galvanometers of different styles are made.

The tangential proportionality of these galvanometers has been tested, on several occasions, in the following manner, with corresponding results in all cases.

Taking galvanometer No. 16, and providing a resistance coil to be put in circuit with coil 3, to make its resistance precisely equal to that of coil 2, and then taking the deflection under different resistances from 10 to 500 ohms, and dividing the tangents of the mean deflections obtained from coil 2, by those from coil 3, we have the following quotients: —

	Coil 2.		Coil 3.		
Ohms Inserted.	Mean Deflection.	Tangents.	Mean Deflection.	Tangents.	Quotients.
10	78° 55′	5.105	56° 50′	1.530	3.33
100	61° 30′	1.842	28° 40′	.5467	3.36
200	46° 55′	1.069	17° 50′	.3217	3.32
500	25° 35′	.4787	8° 12½′	.1442	3.32

Another test made by putting two galvanometers (No. 18 and No. 9, coil 3) into same circuit, gave the following results:—

	Galvanometer No. 18.		Galvanometer No. 9.		
Ohms Inserted.	Mean Deflection.	Tangents.	Mean Deflection.	Tangents.	Quotients.
2	73.9°	3.465	68.9°	2.592	1.34
12	49.9°	1.188	41.5°	.8847	1.34
30	28.3°	.5704	21.7°	.3979	1.35
60	15.8°	.2830	11.8°	.2089	1.35

The near uniformity of these quotients gives evidence of very true Tangent Galvanometers.

The theorem, "*The intensity of currents, as measured by the Tangent Galvanometer, is proportional to the tangents of the angles of deflection,*" may be verified in the following manner:—

Call the terrestrial magnetism, whose tendency is to direct the galvanometer needle to the magnetic meridian, the unit of directive force, and let this unit be represented geometrically by the line $A\ M$ (Fig. 1), which is the radius of the circle $M B M$,—the line $M\ A\ M$ representing the meridian. Now, let an electric current be sent through the galvanometer coil, whose directive force is precisely equal to the terrestrial force, and whose tendency is to direct the needle in a line perpendicular to the meridian, and let this force be represented by the line $A\ B$.

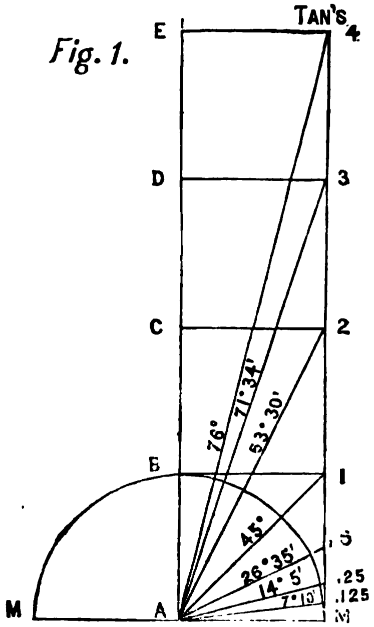
If the terrestrial force could now, for a moment, be suspended, the needle would point due east and west; but the combined action of the two equal forces will direct the needle towards the point of intersection of the line drawn perpendicularly from M, and that drawn horizontally from B at 1, which direction cuts

the quadrant at 45°, the line *M* 1 being the tangent of 45°, which is 1.

Now if we augment the intensity of the current through the coil to twice its present force, which will be 2, and will be represented by the line *A C*, the combined forces *A M* and *A C* will direct the needle towards the point 2. If we now lay a protractor on the circle, we find that the line *A* 2 cuts it at about 63° 30′, of which the tangent is 2.

We may increase the parallelogram erected upon *A M* at pleas-

Fig. 1.



ure, and the two forces combined will always so balance the needle between them as to make it point from *A* diagonally across the parallelogram to its opposite angle, the height of which is the tangent of the angle of deflection.

By inspection of the diagram it is seen that the law holds good in the subdivisions of the force, as at .5, .25, and .125, — a truth admitted by all experimenters as to the relations up to 14°.

The Rheostat contains coils whose several resistances range from $\frac{1}{100}$ of an ohm to 4000 ohms, any one or more of which may be

thrown into the circuit by removing the proper plug or plugs on the top of the rheostat, so that any resistance may be introduced from $\frac{1}{100}$ of an ohm to 10,000 ohms.

In addition to two screw-cups (I. and II.) for connection with the battery and galvanometer, there are two other screw-cups (III. and IV.) for the connection of any conductor whose resistance it is intended to measure; also a switch, *A*, so arranged that the battery current may be directed at pleasure through the rheostat or the conductor. The whole apparatus is packed in a morocco case, nine inches in diameter and seven inches deep, having a handled strap, rendering it convenient for transportation from place to place.

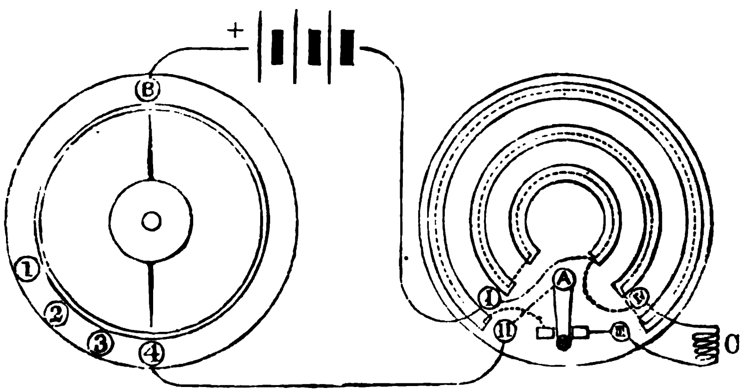


Fig. 2.

The units of electric measurement herein adopted are those of the British Association, viz.:—

OHM, VOLT, AND VEBER.

The OHM is the unit of *resistance*, and is equal to the resistance of a prism of pure mercury, one square millimeter section, and 1.0486 meters long, at 0° *C.*

The VOLT is the unit of *electro-motive force*, which varies but little from the electro-motive force of a standard Daniell's cell.

The VEBER is the unit of *strength*, or *quantity*, or *electro-chemical equivalence* of a current, as it is variously called, and represents that quantity of electricity which flows through a circuit, having an electro-motive force of one volt, and a resistance of one ohm, in one second.

One veber of electricity decomposes —
.00142 grains water, or develops
.000158 grains hydrogen, or
.1721 c.c. mixed gas, at a temp. of
0°C, and barometric pressr. of 760 $^m/_m$.

Resistance of Conductors.

To determine the resistance of any conductor, attach its extremities to the screw-cups III. and IV. of the rheostat, one pole of the battery to *B* of the galvanometer, and the other to I. of the rheostat.

The wire leading from II. of the rheostat is connected with one of the screw-cups 1, 2, 3, 4, of the galvanometer, as may be required.

For resistance of 1000 ohms or more, the No. 1 screw-cup, with a compound or intensity battery, is most suitable; No. 2, from 20 to 1000 ohms; No. 3, from 2 to 20 ohms; and No. 4, with a single large cell of battery — or, what is better, two or more cells arranged for quantity — for very small resistances, 2 ohms or less.

Before measuring small resistances, it is necessary to balance the apparatus, as we would a scale-beam before weighing small quantities. To do this, connect III. and IV. by a short wire, such as may be used in connection with the thing to be measured; the rheostat being fully and carefully plugged. If, now, on turning the switch to the right, the needle goes up, it shows that the short wire does not have resistance enough to balance; therefore, a wire of larger resistance must be selected; on the contrary, if the needle falls back, plugs must be removed sufficient to balance the needle; the amount unplugged must be deducted from the result.

The current is now to be directed through the conductor to be tested, by turning the switch to the right, and the galvanometer deflection noted; the switch is then turned to the left, directing the current through the rheostat. Plugs are now removed to introduce sufficient resistance to bring the needle to the same degree, so that on oscillating the switch back and forth, the needle remains stationary. The resistance of the conductor is now equal to the sum of the resistances of the several rheostat coils introduced.

By this method, any resistance may be directly measured from

$\frac{1}{100}$ of an ohm to 10,000 ohms. Helices, relays, and other electro-magnets are measured in this way.

Measuring and Testing Telegraph Lines.

In using this apparatus for testing in a telegraph office, great care should be taken to avoid the disturbing action of masses of iron, the magnets of instruments, and the currents passing through wires, either under the table or along the walls. All the lines should frequently be tested for conductivity and insulation, and the tests recorded in a book kept for that purpose. These records greatly facilitate the accurate location of faults, whenever it becomes necessary to test for them.

Testing for Conductivity.

This test should be made in fine weather, when the insulation is good. Have all the relays of the line taken out of circuit, and the line connected to earth or ground wire, at distant end, without battery. Arrange the wires as in last diagram (Fig. 2), putting the line wire and the ground wire to III. and IV. When the needle is balanced, the resistance unplugged is equal to the resistance of the line.

No. 9 wire should not exceed 20 ohms per mile of length; and No. 8, 17 ohms. Higher resistance than this indicates defective joints in the line or poor ground connections.

In all these measurements and testings, it is proper to reverse the direction of the current through the line (which is readily done by changing places of the connections at I. and II.), and take the mean of the two results.

Testing for Insulation.

The connections are the same as in the last case, except that the line is open at the distant end, instead of being "grounded." If the line is not very long, or the insulation is good, the resistance will frequently be above the range of the apparatus. This may also happen in testing for conductivity on a very defective wire. In this case another method is adopted.

First arrange the wires as before; then unplug 10,000 ohms resistance, using galvanometer coil No. 1, and an intense main battery. Note the deflection obtained through the whole 10,000 ohms resistance, and call this the maximum of the galvanometer.

Now turn the switch to the right, directing the current through the line, which is open, of course, at the distant end. Note the deflection as before. The tangents of the deflections will each be inversely proportional to the resistance under which it was produced.

Suppose the deflection with the 10,000 ohms to be 30°, giving tangent .5774, while that through the line is 10°, whose tangent is .1763.

Therefore,—

$$.1763 : 10{,}000 \text{ ohms} :: .5774 : 32{,}751 \text{ ohms}.$$

$$\textit{i.e.,}\ \frac{.5774 \times 10.000}{.1763} = 32{,}751 \text{ ohms}.$$

This is the insulation resistance of the line; and this divided by the number of miles in length gives the insulation resistance per mile.

It is proper here to caution those using this apparatus against directing the current from an intense battery through rheostat coils of low resistance, lest they be spoiled by burning. Forty cells of Grove's battery would be likely to greatly damage a 50 ohm coil; and perhaps one of a hundred or two hundred ohms, if the current were directed through it alone. Batteries of no greater strength should be employed than is necessary to accomplish the work desired; 10 or 20 cells of any sulphate of copper battery are sufficient for measuring great resistances.

The daily testings of a line should be recorded in a form something like the following:—

Date.	Maximum. 10,000 Ohms.	No. 1 Wire.			No. 2 Wire.			Weather.
		Conductivity. Resistance Ohms.	Insulation.		Conductivity. Resistance Ohms.	Insulation.		
			Deflection.	Ohms.		Deflection.	Ohms.	
Apl. 1	30°	4050	10°	32,570	5000	30°	10,000	Rain.

*Testing for Location of Faults.**

The principle upon which the methods of distance-testing are founded is that of finding the resistance of the line wire between the testing station and the fault, by the methods above described.

It is very essential that the resistance of each circuit should be frequently measured and recorded, so that when a fault occurs the actual resistance of the line per mile may be known.

If the broken line gives a full ground, its resistance, divided by the resistance per mile, at once gives the distance of the break from the testing station; and if the distant station obtains a like result, the confirmation is complete.

Thus, in a line of 100 miles, if the tests from the two extremities indicate distances of forty-five and fifty-five miles respectively, the locality of the interruption is clearly indicated.

As the fault, however, usually gives a very considerable resistance at the point where the line is in contact with the earth, and the sum of the two resistances, measured from stations at the opposite ends of the lines, greatly exceed the resistance of the line itself when perfect, it is usual in such cases to estimate the fault midway between the two points indicated. Thus, when the respective resistances indicate eighty-six and twenty-six miles, the sum of these exceeds 100 miles by twelve, and therefore half this excess, or six, is deducted from each of the measures; the resistance of the fault having been included in each measurement.

When the line is unbroken, but shows a heavy escape or partial ground, sufficient to weaken signals, two methods are available for determining its locality. The first is that of direct measurement, alternately from each end; the distant end at the same time being insulated, or, in other words, left open, as before explained (p. 42).

In this case the resistance of the fault is measured twice over, and is roughly allowed for by the method of calculation above given.

The Loop Test.

A second and more accurate method, which gives a measure entirely independent of the resistance of the fault, is known as the Loop Test. It is only available, however, in cases where there

* Pope's Modern Practice of the Electric Telegraph, pp. 80–82.

are two or more parallel wires on the same route. In making this test, let the operator proceed as follows.

Make the length to be tested as short as possible, and have all the instruments in circuit taken out; select a good wire similar, if possible, to the one it is required to test. These wires must then be connected together in a loop at the nearest available station beyond the fault, without ground connection. The resistance of the faulty wire, when perfect, must be ascertained. This may be taken from previous records, or it may be found by a test taken as follows.

Connect the apparatus as in the diagram (Fig. 2, also Fig. 4), putting the loop in place of the resistance, to be measured as shown in the diagram; that is, connect the good wire of the loop to III., and the bad wire to IV., and ascertain the resistance as directed (p. 41).

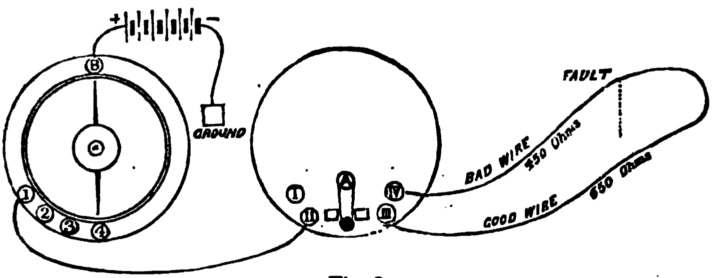


Fig. 3.

Having ascertained the resistance of the loop, arrange the connections, as shown in the above diagram (Fig. 3).

Now turn the switch *A* to the right, and note the deflection; then turn it to the left, and unplug resistance until the same deflection is obtained; the resistance unplugged, deducted from the total resistance of the loop, and divided by 2, is the resistance of the bad wire between the apparatus and the fault.

For example, suppose the resistance of the loop to be 1000 ohms, and 100 ohms have been unplugged to balance the needle; the fault is 450 ohms from IV. Suppose the loop of 1000 ohms is fifty miles in length, then by proportion —

1000 ohms : 50 miles :: 450 ohms : 22.5 miles.

When there is a fault on a line, and there is but one wire, it

may be located by the following method. Ascertain from former record the normal resistance of the line; call this r. Also the resistance of the defective line, when grounded at the distant end, obtained as before directed (p. 42); call this s. Also the resistance when open at the distant end, and call this t; and call the resistance of the wire between the fault and the testing station x; then —

$$x = s - \sqrt{(s^2 + tr) - (ts + rs)}$$

i.e., multiply s by s, and t by r, and add the products together; subtract from this amount t times s, and r times s; subtract the square root of the remainder from s, and the remainder will give the resistance of the wire between the fault and the testing station.

This test should, if practicable, be taken from both ends of the wire, and greater accuracy is secured by taking the mean of several observations.

To Locate a Cross.

The two wires in contact form a loop; open both wires at the nearest available point beyond the cross, and measure the resistance of the loop. Half of this will be the resistance between the testing-station and the cross. The cross itself sometimes has considerable resistance, which would make its true position somewhat nearer than its apparent position.

A cross may also be located by the method given (p. 45), by putting one wire as a ground, which will make an escape at the point where the cross is situated, and which, of course, may be located in the same manner as any other escape, by either of the methods above given.

Conductivity and Resistance.

The conductivity of two conductors of the same metal are directly proportional to the areas of their transverse sections; or, if of round wire, they are directly proportional to the square of their diameters. The resistance of the same wires are inversely proportional to the squares of their diameters.

Specific Conductivity and Resistance.

The relative specific resistance of two metals may be determined by taking the resistance of a wire of each, of a given length

and diameter; their resistances will denote their relative specific resistances, or they may be computed from wires of different diameters (their lengths being equal), by the following formula:—

$D =$ diameter of standard wire.
$R =$ resistance of do.
$d =$ diameter of wire to be tested.
$r =$ resistance of do.
$d^2 : R :: D^2 : r.$

i.e.,—

$$\frac{D^2\ R}{d^2} = r.$$

Suppose we take as a standard a copper wire, ten feet long, No. 26 by the American gauge (Darling, Brown, and Sharp), whose diameter by the following table is sixteen mils (thousandths of an inch), and find its resistance to be .44 ohm, and another wire of same length, No. 30, whose diameter is ten mils; the square of the latter is 100, and that of the former 256.

$$\frac{256 \times .44}{100} = 1.13.$$

1.13 ohms, therefore, would be the resistance of the No. 30 wire, if the specific resistances of the metals of which the two wires are composed are equal; but on trial we find its resistance to be 1.9 ohms.

Assuming 100 as the specific resistance of the standard metal

$$1.13 : 100 :: 1.9 : 168;$$

the specific resistance of the tested metal is, therefore, 68 per cent. greater than the standard, *i.e.*, 168 to 100.

Brown and Sharp's sheet metal gauge, which determines the diameter of a wire to the $\frac{1}{1000}$ of an inch, is the best measure for this purpose.

TABLE OF DIAMETERS OF WIRES EXPRESSED IN MILS (THOUSANDTHS OF AN INCH).

Number.	American Gauge.	Birmingham Gauge.	Number.	American Gauge.	Birmingham Gauge.
	Mils.	*Mils.*		*Mils.*	*Mils.*
0000	460.	454.	19	35.89	42.
000	409.64	425.	20	31.96	35.
00	364.80	380.	21	28.46	32.
0	324.95	340.	22	25.35	28.
1	289.30	300.	23	22.57	25.
2	257.63	284.	24	20.10	22.
3	229.42	259.	25	17.90	20.
4	204.31	238.	26	15.94	18.
5	181.94	220.	27	14.19	16.
6	162.02	203.	28	12.64	14.
7	144.28	180.	29	11.26	13.
8	128.49	165.	30	10.02	12.
9	114.43	148.	31	8.93	10.
10	101.89	134.	32	7.95	9.
11	90.74	120.	33	7.08	8.
12	80.81	109.	34	6.30	7.
13	71.96	95.	35	5.61	5.
14	64.08	83.	36	5.00	4.
15	57.07	72.	37	4.45	
16	50.82	65.	38	3.96	
17	45.26	58.	39	3.53	
18	40.30	49.	40	3.14	

Or the following method may sometimes be more available, and is more exact.

It has been determined (Latimer Clark on Electric Measurement, p. 64) that one nautical mile, 2029 yards pure copper wire weighing one pound, has at 60° Fahr. 1155.5 ohms resistance,

$$1 \text{ lb.} = 7000 \text{ Troy grains.}$$

2029 yards : 7000 grains :: 10 yards : 34.5 grains, and 2029 yards : 1155.5 ohms :: 10 yards : 5.695 ohms..

Therefore,

10 yards pure copper wire, weighing 34.5 grains, has 5.695 ohms resistance.

The resistance of a given length of wire is inversely propor-

tional to its weight; hence, if ten yards of wire weigh ten times as much, 345 grains, its resistance will be one-tenth = .57 ohm.

If, on trial, we find its resistance to be greater, say .67 ohm, its conductivity is less than the pure copper, in the inverse ratio of the resistance; that is,

$$67 : 57 :: 100 : 85,$$

or the metal has a conductivity of 85, the pure being taken at 100.

Suppose ten yards of pure copper weigh 173.4 grains, and have a resistance of 1.2 ohms.

$$173.4 \text{ grains} : 5.695 \text{ ohms} :: 34.5 \text{ grains} : 1.133 \text{ ohms},$$

i.e.,

$$\frac{34.5 \times 5.695}{173.4} = 1.133.$$

For specific resistance,

$$1.133 : 100 :: 1.2 : 105.91,$$

and for specific conductivity, the same proportion inversely,

$$\frac{1.133 \times 100}{1.2} = 94.2.$$

Therefore, taking both the resistance and the conductivity of pure copper at 100, the specific resistance of the specimen tested is 105.9, and its specific conductivity 94.2.

For convenience we may take the product of 34.5 grains × 5.695 ohms, 196.4775, as a constant quantity, to be divided by the weight in grains of any specimen of ten yards of copper wire. This will give the resistance in ohms, which the specimen would have if pure. Dividing this (multiplied by 100) by the actual resistance we have the specific conductivity, or dividing the actual resistance (multiplied by 100) by this we have the specific resistance.

Effect of Temperature.

The resistance of copper changes about .208 per cent for each degree Fahr.,* which is to be added or subtracted as the temperature is below or above 60°.

* On Electric Measurement. By Latimer Clark, p. 68.

If a wire has 22.73 ohms resistance at 70°, what will it have at 60°?

$$22.73 - (22.73 \times .00208 \times 10^\circ) = 22.257.$$

The following table will be found convenient in making corrections for temperature.

TABLE FOR CALCULATING THE RESISTANCE OF COPPER AT DIFFERENT TEMPERATURES.

To Reduce from Lower Temperature to Higher, multiply the Resistance by the Number in Column 2.				To Reduce from Higher Temperature to Lower, multiply the Resistance by the Number in Column 4.			
No. of Degrees.	Column 2.	No. of Degrees.	Column 2.	No. of Degrees.	Column 4.	No. of Degrees.	Column 4.
0	1.			0	1.		
1	1.0021	16	1.0341	1	0.9979	16	0.9670
2	1.0042	17	1.0363	2	0.9958	17	0.9650
3	1.0063	18	1.0385	3	0.9937	18	0.9629
4	1.0084	19	1.0407	4	0.9916	19	0.9609
5	1.0105	20	1.0428	5	0.9896	20	0.9589
6	1.0127	21	1.0450	6	0.9875	21	0.9569
7	1.0148	22	1.0472	7	0.9854	22	0.9549
8	1.0169	23	1.0494	8	0.9834	23	0.9529
9	1.0191	24	1.0516	9	0.9813	24	0.9509
10	1.0212	25	1.0538	10	0.9792	25	0.9489
11	1.0233	26	1.0561	11	0.9772	26	0.9469
12	1.0255	27	1.0583	12	0.9751	27	0.9449
13	1.0276	28	1.0605	13	0.9731	28	0.9429
14	1.0298	29	1.0627	14	0.9711	29	0.9409
15	1.0320	30	1.0650	15	0.9690	30	0.9390

Resistance of Batteries.

In determining the interior resistance of batteries, the resistance of the galvanometer coil used, if it has any appreciable resistance, with the connections must be known. In taking deflections where accuracy is required, the direction of the current through the galvanometer should be reversed, and the mean of the two deflections taken; for we can scarcely fail to observe some difference.

If we have no adjustable rheostat, we must be provided with one or more standard coils, whose resistances are correctly known;

one or two ohms is sufficient when a single cell is to be measured, but more when a number of cells are to be measured.

The following formula brings us to a simple and correct rule:—

Let e = electro-motive force.
r = resistance of the battery.
r^1 = a known resistance to be inserted.
s = strength of current = tan. of deflection.
s^1 = tan. of deflection when r^1 is inserted.

According to Ohm's law,

$$\frac{e}{r} = s \text{ and } \frac{e}{r + r^1} = s^1.$$

Two equations, involving the two unknown quantities e and r, which, cleared of fractions, become—

$$e = rs, \qquad \text{1st equation.}$$
$$e = rs^1 + r^1s^1, \quad \text{2d} \quad \text{do.}$$

Eliminate e by substituting rs of the 1st equation for e of the 2d equation—

$$rs = rs^1 + r^1s^1, \qquad \text{transferring } rs^1;$$

$rs - rs^1 = r^1s^1$, and dividing by $s - s^1$, we have

$$r = \frac{r^1s^1}{s - s^1},$$

or the following simple proportion,—

$$s - s^1 : r^1 :: s^1 : r.$$

If the galvanometer has resistance, subtract it from the result, and we have the interior resistance of the battery.

Another method is sometimes employed, in which the resistance of the galvanometer must be null, and the wire of an adjustable rheostat so large as not to be essentially heated by the current.

$\frac{e}{r} = s$ = tangent of deflection, and

$\frac{s}{2}$ = tan. of deflection when a resistance is inserted equal to the interior resistance.

Therefore, divide the tangent of deflection by 2, and find the

degree corresponding to this half tangent; then interpose rheostat coils to bring the needle to the same degree. The resistance thus interposed will be equal to the interior resistance.

The resistance of two cells of equal strength, or two series of two or more cells, each of equal strength, may be obtained by connecting two like poles of the two together, so that they neutralize each other, and connecting them by screw-cups III. and IV., and taking their resistance as we do that of any conductor.

The following method, too, discovered and first used by the writer is found to be correct and reliable. The cell to be tested is connected between III. and IV., using two or more cells for the main battery. The switch being to the left, the deflection caused by the main battery is noted. On turning the switch to the right, the force of the cell is added to that of the main battery, and the deflection is increased. Now reverse the poles of the cell so that its force opposes that of the main, and the deflection is much diminished. Add the tangent of the smaller to that of the larger deflection and divide by 2. Find the degree corresponding to this mean tangent. Then turn the switch to the left, and introduce rheostat resistance to bring the needle to the same degree. The amount introduced will show the resistance of the cell.

Constant Multiplier.

To determine the electro-chemical equivalent of a current by a tangent galvanometer, it is necessary to find a number by which the multiplication of the tangent of its degree of deflection will give the equivalent sought.

This is done in various ways. That recommended and employed by most authors is by the electrolysis of water in the voltameter, and the production of its elementary gases, the volume of which, when properly corrected for temperature, pressure, and moisture, is directly proportional to the strength of the current.

The correction may be made by the following formula.

$v^1 =$ volume of gas observed.
$v =$ vol. corrected for temp., pressure, and moisture.
$b^1 =$ barometric pressure observed.
$b =$ same corrected for temperature.
$e =$ tension of vapor of water at t° C.

t = the number of degrees above freezing point.

$\frac{1}{273}$ = Regnault's co-efficient of expansion for each degree C.

$$v = \frac{273\ v^1}{273 + t} \times \frac{b - e}{b}$$

Barometric Correction.

The barometric column is to be corrected for temperature, for which we may employ the following table, where the scale is of wood, graduated for millimeters; or we may multiply the co-efficient of expansion for 1° C., .00018153, by the number of degrees C., and the product by the height in millimeters, and subtract the last product from the apparent height.

The co-efficient of expansion of glass, for each degree, is .0000092; and of brass, .0000188. Where the scale is of one of these materials, its co-efficient must be subtracted from that of mercury.

TABLE FOR CORRECTION OF BAROMETRIC INDICATIONS, measured by wooden scale in millimeters, calculated from the co-efficient of Regnault, .018153, the dilation of mercury from 0° C. to 100° C. That for 1° C. is .00018153.

°C.	1 m/m.	°C.	1 m/m.	°C.	1 m/m.
1	.00018	16	.00290	31	.00563
2	.00036	17	.00309	32	.00581
3	.00054	18	.00327	33	.00599
4	.00073	19	.00345	34	.00617
5	.00091	20	.00363	35	.00635
6	.00109	21	.00381	36	.00654
7	.00127	22	.00399	37	.00672
8	.00145	23	.00418	38	.00690
9	.00163	24	.00436	39	.00708
10	.00182	25	.00454	40	.00726
11	.00200	26	.00472	41	.00744
12	.00218	27	.00590	42	.00762
13	.00236	28	.00508	43	.00781
14	.00254	29	.00526	44	.00799
15	.00272	30	.00545	45	.00817

Multiply the co-efficient for the number of degrees C. by the apparent height in millimeters, and subtract the product from the apparent height.

The following table gives the factor e:—

TABLE OF THE TENSION OF AQUEOUS VAPOR, expressed in millimeters of mercury, at 0° C. for each degree from 0° C. to 35° C. (Regnault).

°C.	Tension in m/m.	°C.	Tension in m/m.	°C.	Tension in m/m.
0	4.600	12	10.457	24	22.184
1	4.940	13	11.062	25	23.550
2	5.302	14	11.906	26	24.998
3	5.687	15	12.669	27	26.505
4	6.097	16	13.635	28	28.101
5	6.534	17	14.421	29	29.781
6	6.998	18	15.357	30	31.548
7	7.492	19	16.346	31	33.405
8	8.017	20	17.391	32	35.359
9	8.574	21	18.495	33	37.410
10	9.165	22	19.659	34	39.565
11	9.792	23	20.888	35	41.827

Suppose, $v^1 = 154$ c.c. in 200 minutes.
$b^1 = 760$ m/m.
$b = 757$ „
$e = 18.5$ „
$t = 21°$ C.

$$v = \frac{154 \times 273}{273 + 21} = \frac{42042}{294} = 143$$

$$757 - 18.5 = \frac{738.5}{757} = .9755$$

$$v = 143 \times .9755 = 139.5 \text{ c.c. in 200 min.}$$
$$= .6975 \text{ c.c. per minute.}$$
$$= .01162 \text{ „ „ second.}$$

Reducing this to vebers,

.1721 c.c. : 1 veber :: .01162 c.c. : .067518 vebers per second.

Now dividing this product by the mean tangent of the galvanometer deflection under which it was produced, 1.1189,

we have .060343, *a constant multiplier*,

by which we may multiply the tangent of any deflection of that same galvanometer, and thereby obtain the equivalent of the current producing it in vebers per second.

We may now obtain the weight in grains per second of any metal or element whose salt we may submit to electrolysis, with this galvanometer in circuit, by simply multiplying the tangent of deflection by this constant, the product by .000158 grains (the hydrogen equivalent of one veber per second), and this product by the chemical equivalent of the element.

Suppose a salt of copper has been submitted to the same current with the voltameter in the preceding example, how much copper would have been deposited per second?

1.1189 × constant, .060343, × .000158 grs. hydrogen × 31.7, chem. equivalent of copper,
= .000338 grs. copper per second.
= .0203 „ „ „ minute.

Multiplying .6975 c.c. per minute by .0292, the copper equivalent of 1 c.c., we have the same answer, .0203 grains copper per minute; thus verifying the calculation.

Hence we have the following

TABLE OF EQUIVALENTS.

Veber. 1	:	Element.	Chemical Equivalent.	∴	Veber. .000158	:	Grains Troy per second.
„		Hydrogen	1.0		„		.000158
„		Water	9.0		„		.001422
„		Zinc	32.5		„		.005135
„		Copper	31.7		„		.005009
„		Silver	108.0		„		.017064
„		Nickel	29.0		„		.004580
„		Gold	196.7		„		.031080

Electro-Motive Force.

We are now possessed of the elements for determining the electro-motive force of a battery.

Referring to the formula before given (p. 51) for determining the interior resistance of a battery, and to the applications of Ohm's law, to be found in all modern books on electricity, we see that

$$rs = e,$$

i.e., the whole resistance in *ohms*, multiplied by the strength in *vebers*, gives the electro-motive force in *volts*.

Such are the laws of electrolysis, as discovered and laid down by Faraday, who announced that "*the electrolytic action of a current is the same in all its parts; that the same electric current decomposes chemically equivalent quantities of all the bodies which are traversed;*" from which it follows that "*the weights of elements separated in these electrolytes are to each other as their chemical equivalents;*" and that "*the quantity of a body decomposed in a given time is proportional to the intensity of the current.*"

On this is founded the use of Faraday's voltameter, in which the intensity of a current is ascertained from the quantity of water which is decomposed in a given time.* It would seem, then, reasoning *à priori*, that a *constant* multiplier obtained for a true tangent galvanometer would give correct and reliable results in all cases of electrolysis; that any one engaged in electro-plating of any kind, having one of these galvanometers in the circuit, might readily know how many grains of the metal is deposited per second, by multiplying the tangent of the angle of deflection by the *constant*, and the product by the proper number in the right hand or fifth column of the foregoing table of equivalents (p. 55). And so it would be if we were always dealing with elements that were perfectly pure, and with their salts that were perfectly neutral; but such perfection and purity we do not find in ordinary practice. Results therefore can be taken only as approximations to truth, which will be more or less remote as our materials are more or less impure.

In the investigation of these laws, the writer has made a great number of tests with water voltameters, and those of copper, silver, and gold, the results of which were at first very discouraging; no two being found to agree in their equivalents.

But finally two copper baths, one of sulphate of copper, and one of nitrate of copper, were tried. The plates to be used were first coated with reguline copper, by deposition from solutions in which anodes were used of the purest copper to be obtained. Now, by using one of such plates as anode and another as cathode, and occasionally reversing the current until the solutions became so entirely neutral that the weight of metal lost from the anode and that gained upon the cathode were equal, and the transport in the two voltameters were also equal, these were therefore taken as giving correctly equivalent proportions for copper.

* Ganot's Physics, p. 653.

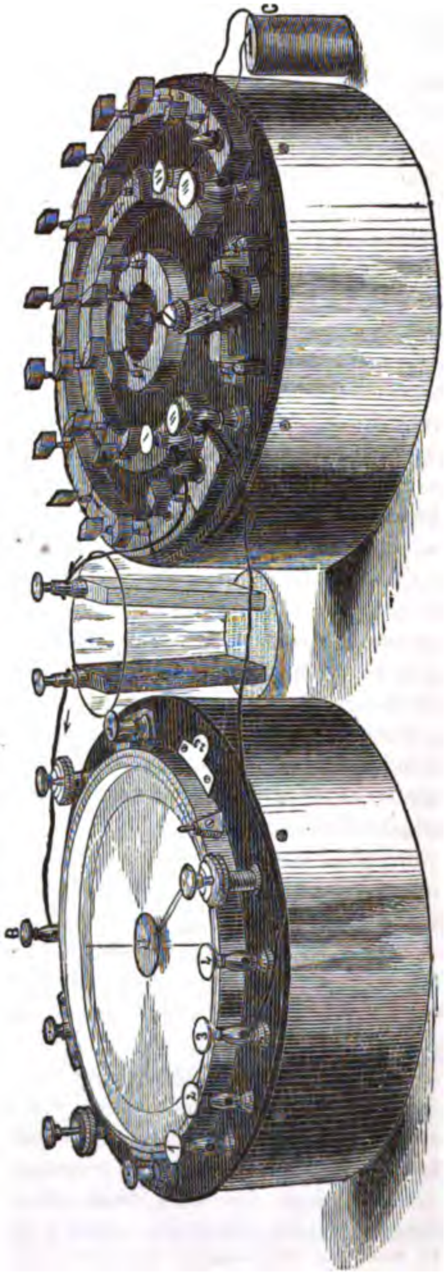
But in the electrolysis of acidulated water by the same current, it was found that no such voltameter as is described by Faraday or other authors would develop a measure of corrected gas sufficient to amount to the same equivalent, — a circumstance evincing clearly the fact, that between electrodes of any considerable size a part of the current is conducted without decomposing the water.

But by fixing two pieces of No. 29 platinum wire across a glass tube, of an interior diameter of four-tenths of an inch, and a length of about six inches (the tube being broken and the wires put across and melted in), a voltameter was at length constructed which gave, in the same circuit, a volume of gas precisely equivalent to the copper deposited in the copper voltameters; and from this true multipliers are obtained.

In common practice every operator can easily obtain for himself the constant multiplier, which, for his own galvanometer and bath, will determine the amount of work performed by the current, with as much accuracy as is attainable by weights and measures.

To do this let him take a few articles (such as present large surfaces in proportion to their weights are best), and accurately weigh them; then let them be placed in the bath and remain a suitable time, which must be accurately noted, together with the mean deflection of the galvanometer. Now let them be accurately weighed again, and the weight per minute estimated in grains; dividing the number of grains by the tangent of the mean deflection the constant sought is found.

Fig. 4.



BRADLEY'S APPARATUS FOR ELECTRIC MEASUREMENT.

2. On Sympathetic Vibrations, as exhibited in Ordinary Machinery. By Joseph Lovering, of Cambridge, Mass.

At the meeting of this Association in Burlington, I showed some experiments in illustration of the *optical method* of making sensible the vibrations of the column of air in an organ-pipe. At the Chicago meeting, I demonstrated the way in which the vibrations of strings could be studied by the eye in place of the ear, when these strings were attached to tuning-forks with which they could vibrate in sympathy; substituting for the small forks, originally used by Melde, a colossal tuning-fork, the prongs of which were placed between the poles of a powerful electro-magnet. This fork, which interrupted the battery current, at the proper time, by its own motion, was able to put a heavy cord, thirty feet in length, in the most energetic vibration, and for an indefinite time. I propose, at the present time, to speak of those sympathetic vibrations which are pitched so low as not to come within the limits of human ears, but which are felt rather than heard, and to show how they may be seen as well as felt.

All structures, large or small, simple or complex, have a definite rate of vibration, depending on their. materials, size, and shape, and as fixed as the fundamental note of a musical cord. They may also vibrate *in parts*, as the cord does, and thus be capable of various increasing rates of vibration, which constitute their harmonics. If one body vibrates, all others in the neighborhood will respond, if the rate of vibration in the first agrees with their own principal or secondary rates of vibration, even when no more substantial bond than the air unites a body with its neighbors. In this way, mechanical disturbances, harmless in their origin, assume a troublesome and perhaps a dangerous character, when they enter bodies all too ready to move at the required rate, and sometimes beyond the sphere of their stability.

When the bridge at Colebrooke Dale (the first iron bridge in the world) was building, a fiddler came along and said to the workmen that he could fiddle their bridge down. The builders thought this boast a fiddle-de-dee, and invited the itinerant musician to fiddle away to his heart's content. One note after another was struck upon the strings until one was found with which the bridge was in sympathy. When the bridge began to shake violently,

the incredulous workmen were alarmed at the unexpected result, and ordered the fiddler to stop.

At one time, considerable annoyance was experienced in one of the mills in Lowell, because the walls of the building and the floors were violently shaken by the machinery: so much so that, on certain days, a pail of water would be nearly emptied of its contents, while on other days all was quiet. Upon investigation it appeared that the building shook in response to the motion of the machinery only when that moved at a particular rate, coinciding with one of the harmonics of the structure; and the simple remedy for the trouble consisted in making the machinery move at a little more or a little less speed, so as to put it out of time with the building.

We can easily believe that, in many cases, these violent vibrations will loosen the cement and derange the parts of a building, so that it may afterwards fall under the pressure of a weight which otherwise it was fully able to bear, and at a time, possibly, when the machinery is not in motion; and this may have something to do with such accidents as that which happened to the Pemberton Mills in Lawrence. Large trees are uprooted in powerful gales, because the wind comes in gusts; and if these gusts happen to be timed in accordance with the natural swing of the tree, the effect is irresistible. The slow vibrations which proceed from the largest pipes of a large organ, and which are below the range of musical sounds, are able to shake the walls and floors of a building so as to be felt, if not heard, thereby furnishing a background of noise on which the true musical sounds may be projected.

We have here the reason of the rule observed by marching armies when they cross a bridge; viz., to stop the music, break step, and open column, lest the measured cadence of a condensed mass of men should urge the bridge to vibrate beyond its sphere of cohesion. A neglect of this rule has led to serious accidents. The Broughton bridge, near Manchester, gave way beneath the measured tread of only sixty men who were marching over it. The celebrated engineer, Robert Stephenson, has remarked* that there is not so much danger to a bridge, when it is crowded with men or cattle, or if cavalry are passing over it, as when men go over it in marching order. A chain-bridge crosses the river Dordogne on the road to Bordeaux. One of the Stephensons

* Edin. Phil. Journ. v. p. 255.

passed over it in 1845, and was so much struck with its defects, although it had been recently erected, that he notified the authorities in regard to them. A few years afterwards it gave way when troops were marching over it.*

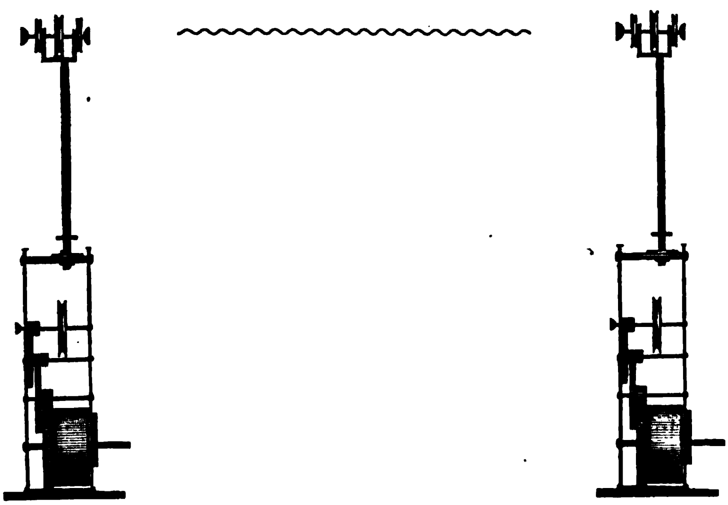
A few years ago, a terrible disaster befell a battalion of French infantry, while crossing the suspension-bridge at Angiers, in France. Reiterated warnings were given to the troops to break into sections, as is usually done. But the rain was falling heavily, and, in the hurry of the moment, the orders were disregarded. The bridge, which was only twelve years old, and which had been repaired the year before at a cost of $7000, fell, and two hundred and eighty dead bodies were found, besides many who were wounded. Among the killed or drowned were the chief of battalion and four other officers. Many of the guns were bent double, and one musket pierced completely through the body of a soldier. The wholesale slaughter at the bridge of Beresina, in Russia, when Napoleon was retreating from Moscow, in 1812, and his troops crowded upon the bridge and broke it, furnishes a fitting parallel to this great calamity.

When Galileo set a pendulum in strong vibration by blowing on it whenever it was moving away from his mouth, he gave a good illustration of the way in which small but regularly repeated disturbances grow into consequence. Tyndall tells us that the Swiss muleteers tie up the bells of the mules, for fear that the tinkle should bring an avalanche down. The breaking of a drinking-glass by the human voice, when its fundamental note is sounded, is a well-authenticated feat; and Chladni mentions an innkeeper who frequently repeated the experiment for the entertainment of his guests and his own profit. The nightingale is said to kill by the power of its notes. The bark of a dog is able to call forth a response from certain strings of the piano. And a curious passage has been pointed out in the Talmud, which discusses the indemnity to be claimed when a vessel is broken by the voice of a domestic animal. If we enter the domain of music, there is no end to the illustrations which might be given of these sympathetic vibrations. They play a conspicuous part in most musical instruments, and the sounds which these instruments produce would be meagre and ineffective without them.

In the case of vibrations which are simply mechanical, without

* Smiles's Life of Stephenson, p. 390.

being audible, or at any rate musical, the following ocular demonstration may be given. A train of wheels, set in motion by a strong spring wound up in a drum, causes a horizontal spindle to revolve with great velocity. Two pieces of apparatus like this are placed at the opposite sides of a room. On the ends of the spindles which face one another are attached buttons about an inch in diameter. The two ends of a piece of white tape are fastened to the rims of these buttons. When the spindles, with the attached buttons, revolve, the two ends of the tape revolve, and in such directions as to prevent the tape from twisting, unless the velocities are different. Even if the two trains of wheels



move with unequal velocities, when independent of each other, the motions tend to uniformity when the two spindles are connected by the tape. Now, by moving slightly the apparatus at one end of the room, the tape may be tightened or loosened. If the tape is tightened, its rate of vibration is increased, and, at the same time, the velocity of the spindles is diminished on account of the greater resistance. If the tape is slackened, its rate of vibration is less, and the velocity of the spindles is greater. By this change we can readily bring the fundamental vibration of the tape into unison with the machinery, and then the tape responds by a vibration of great amplitude, visible to all beholders. If we begin gradually to loosen the tape, it soon ceases to respond,

on account of the twofold effect already described, until the time comes when the velocity of the machinery accords with the first harmonic of the tape, and the latter divides beautifully into two vibrating segments with a node at the middle. As the tension slowly diminishes, the different harmonics are successively developed, until finally the tape is broken up into numerous segments only an inch or two in length. The eye is as much delighted by this visible music as the ear could be if the vibrations were audible; and the optical demonstration has this advantage, that all may see, while few have musical ears. A tape is preferred to a cord in this experiment, because it is better seen, and any accidental twist it may acquire is less troublesome. The wood-cuts on the opposite page represent the apparatus used, drawn on a scale of one inch to five inches.

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3. Compressed Air as a Motor. By William Jordan, of Galena, Illinois.

The very alarming and exhausting consumption of the various kinds of fuel for steam boilers indicates the necessity of turning our attention to Water Streams as Motors.

But some may think this only ideal. This has always been said of any change proposed by the members of scientific associations, and their predecessors, for at least fifty years back. All honor to those far-seeing, sagacious, persevering, investigating, persecuted men of science, who gave and established the various changes and improvements, although taunted at the time as mere fools, — the beautiful principle of the condensing steam-engine being perfected by Watt. But I remember the oscillating beam made of wood, and boilers of lead, two inches thick: now for the same purpose $\frac{3}{16}$ of an inch of steel plate is used. The introduction of spinning by power machinery, and the dandy, or hand-loom, now superseded by the power-loom, was fiercely opposed by nearly all parties, but especially by the mistaken operatives. The very important sealing-wax and wafers, flint and steel, candles and sperm lamps, sedans, pack-horses, slow wagons, and canal-boats have

almost disappeared. In their place we have railways, telegraphs, shoe, sewing, and improved agricultural machines. All these conveniences were, at their introduction, scoffed at, and had to be forced into use.

We formerly sought a populous place to make a railway: now we make one to settle, populate, and enrich a place. Hence the Northern Pacific. All honor to its promoters.

And now I come to the question of fostering manufactories requiring cheap, safe, abundant, and ready power. However Utopian it may seem, please allow me to say that I have many pleasing dreams, suggestions, and inferences, that, if I am so favored as to possess the life hereafter, I shall not be debarred from knowing the situation and social improvements of those left, and in fifty more years find that nearly all the power used for manufacturing will be derived from water-streams, currents, and ocean tides, in lieu of expensive, uncontrolled, and dangerous steam, as at present.

I suggest that there be erected on land, near a swift slough, at the nearest place on the Mississippi or other stream, self-regulating, under-shot water-wheels, or immersed Archimedean screws, or propellers, with gearing to cylinders, to compress the atmosphere through a large reserve air-chamber and main pipe or tube, laid on or under ground to the city, and smaller branch pipes, cut-off cocks, &c., to the various manufactories. The inducement to manufacture with power anywhere in the city, without purchasing a special water-lot, and without fire, heat, or danger from steam-boiler explosions, would be great; and the good effect of the liberated air would have a valuable sanitary effect, by removing the malaria and vitiated foul gases. After the first outlay, the running expenses would be very little; and, after one example, I think that city governments would see it to be to their advantage and policy to supply power of this description gratuitously.

4. On Zonochlorite, a New Hydrous Silicate from Neepigon Bay, North Shore of Lake Superior, B. A. By A. E. Foote, of the Agricultural College, Iowa.

In 1867, during a natural history excursion through that portion of British America that borders upon the north shore of Lake Superior, I examined some minerals in possession of one of the traders of Hudson's Bay Company.

Most of these were varieties of quartz, but among them was what he called a green agate. I succeeded in obtaining a very small piece from him. This I examined in the winter of 1867 and 1868, and pretty fully satisfied myself that it was something new. The specimen that I had was too small to admit of quantitative tests, and I therefore postponed making public my discovery. In the summer of 1868 I organized an exploring party of thirteen men, having for my main object the discovery of the locality of this mineral. In this I fully succeeded.

It occurs in the amygdaloid trap on the shore of a small island which lies off the mouth of Neepigon Bay; the largest bay on the north shore of Lake Superior.

It is associated with laumonite, stillbite, prehnite, quartz in the varieties, amethyst, agate, carnelian, copper, datholite, and calcite. The mineral is found massive, banded with different shades of dark green. It has a hardness of 6½ to 7½, and is quite tough. Its specific gravity is 3.113, on the average of 16; highest 3.157, lowest 3.042. Heated in a test-tube, its powder yields water, and becomes brownish-white. The thin edges fuse with difficulty to a dark glass.

With borax and the fluxes it gives reactions for iron. In HCl it dissolves, with the separation of silicic acid, as a fine powder. The spectroscope shows lime and soda, and qualitative tests prove alumina and iron. The water was determined by igniting the powdered mineral in a glass tube ten inches long, closed at one end, and a quarter of an inch in calibre.

The water was condensed in the tube, and was removed by evaporation. It was found that less than one-tenth per cent was lost by volatilization.

The average of a number of estimations gave as the percentage of water 8.7; the highest, 12.9; the lowest, 7.03.

The lime, silica, iron, alumina, and soda were estimated by the ordinary methods detailed in Fresenius. The physical characters of the mineral seem to me to be so marked as to be sufficient to indicate a new mineral, and this also is the opinion of Professors Gustav Rose and Des Cloiseaux, as well as of many others to whom I have shown it.

On account of its hardness and toughness it is susceptible of a high polish, and may be used as a gem. I propose the name "Zonochlorite," from ζώνη, a band, χλωρὸς, green, and λίθος, stone.

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5. On Soil Analyses and their Utility. By Eugene W. Hilgard, of Oxford, Miss.

In the "American Journal of Science" for September, 1861, Professor S. W. Johnson published a criticism on the "Soil Analyses of the Geological Surveys of Kentucky and Arkansas," whose strictures, to a great extent eminently just, appear to have so impressed the scientific public in this country, that few, if any, soil analyses have since then been made in connection with any state or national survey, excepting that of the State of Mississippi, where the work already begun was continued, either by myself, or under my charge or recommendation, by others. Holding myself responsible for this departure from the generally adopted views, I propose in the present paper to discuss specially Professor Johnson's objections, and to give my reasons for persisting in a course of research that has, more than once, secured for myself and my co-laborers the compassionate sympathy of true believers. While I consider the work far from being as complete as it should be, and whereas for that, as well as other reasons, its publication in detail may be delayed for some time, yet I think what can now be said of sufficient importance to be brought before this meeting.

I propose, in this discussion, to maintain the mainly practical standpoint assumed by Professor Johnson himself. I shall therefore leave out of consideration the performance of such exhaustive investigations of *all* the physical and chemical properties of the soil, as have been made in some cases, for special purposes; *e.g.*, by Professor Mallet, on some of the cotton soils of Alabama. If the investigation of each soil, to possess practical importance, requires from three to six months' labor, we may as well, for practical purposes, consider such researches out of the question for the present. We want something analogous to the metallurgical assay of minerals, as distinguished from their complete ultimate analysis. So far, therefore, as the agricultural qualities of a soil may be inferred and approximately estimated by an experienced eye, I would relieve the chemist from the exact numerical determination, *e.g.*, of the power of absorbing heat from the sun, the specific heat, the water-holding power, the capillary coefficients, &c. However necessary for theoretical investigations, I hold that, for practical purposes, these laborious determinations may in most cases be dispensed with; since from what has already been done, or what can be done with a few typical soils, we may infer the comparative magnitude of these coefficients with a sufficient degree of approximation.

The amount of labor bestowed on each soil by Dr. Peter, as reported in the Kentucky and Arkansas surveys, approaches very closely the limit beyond which the *immediate* advantages to be derived from such knowledge of soils as analysis may impart would seem, to many, disproportioned to the expenditure involved. How very modest we are truly, when a purely scientific object is involved, whose immediate practical application is not obvious at a glance! In what other branch of technical science would it be thought admissible to proceed without obtaining such knowledge of the prime materials as chemistry may afford, even if *no* immediate application of this knowledge be foreseen? Our public treasuries are constantly drawn upon for hundreds of thousands of dollars, in behalf of objects of at least questionable usefulness. Yet Professor Johnson seems to have thoroughly satisfied our state geologists that they are not justified in giving the virgin soils of their respective States the benefit of such light as chemistry may even now confessedly afford; apart from the important general inferences which may fairly be expected to be drawn hereafter from the history of their cultivation. How are we to

advance in our knowledge of soils, if we abandon as hopeless the determination of their chemical character? Are the proofs that have been brought against the utility of soil analyses really of such a character as to justify so grave an omission? — an omission, too, which in many cases cannot hereafter be supplied. Even in the comparatively youthful State of Mississippi, I have found difficulty in obtaining reliable specimens of some soils, whose great productiveness had led to their cultivation by the earliest settlers, over the entire area of their occurrence.

I question the propriety of this omission, and the justice of the *testimonium paupertatis* thus inflicted upon agricultural and analytical chemistry.

To define my position, I premise that —

1. I fully agree with Professor Johnson as to the comparative uselessness of a single analysis giving the percentages of soil ingredients found *in ordinary cases*. It is only when such analysis demonstrates the *great abundance*, or *very great deficiency*, of one or several primarily important ingredients, that, by itself, it conveys information of considerable practical importance. Note, that such cases are not altogether infrequent, even in virgin soils.

2. I agree that an "average soil" is a *non ens*, except as referred, comparatively, to a *particular set of soils closely related in their origin*.

3. Also, that the claim of being able to detect the minute differences caused by cropping without return to the soil is precarious, and perhaps beyond the power of our present analytical resources.

4. I further admit that, ordinarily, the analysis of soils long cultivated, and treated with manures, can give but little and very partial information as to the condition and composition of the soil; from the great difficulty, if not impossibility, of obtaining fair representative specimens.

5. Furthermore, that to designate soils by the names of the Cretaceous, Carboniferous, or Silurian strata they may happen to overlie, is very loose practice; since, in most cases, they are derived from Quaternary deposits, which may or may not have been influenced in their composition by the subjacent rocks.

On the contrary I demur, in the first place, to the broad assertion that "it is practically impossible to obtain average specimens

of the soil," as inapplicable to a very large class, especially of virgin soils, covering large areas with a uniformity of character corresponding to that of subjacent formations, from which they have been directly derived, by substantially identical and uniform, or uniformly variable, processes.

The importance of this exception is not, it is true, very obvious in the stony fields of New England (such as discouraged Professor Johnson in his vacation trip to Northern New York), or, in fact, in any district where a great variety of formations has directly contributed toward forming the soil, and "chunks" of undecomposed minerals are diffused through it. In such cases, the analysis of the rock which has predominantly contributed to the mass of the soil proper would be a more correct index of the prevalent characteristics of the latter, than if itself were taken in hand. And from such analyses we could at least deduce what ingredients, and in what form, it would certainly be *useless* to add to the soil.

But when we come to the great plains of the West and Southwest, whose soils are consistently derived from widespread Quaternary deposits, composed of materials almost impalpable save as regards silicious sand; or even the rolling uplands of the Gulf States, whose subsoil stratum of "yellow loam" can only be diluted, but not otherwise changed, by the admixture of the underlying drift, leached long ago of every thing soluble in carbonated water, or available to plants: the objection based upon the supposed impossibility of securing representative specimens becomes obviously untenable; as I shall hereafter show from the close correspondence in the composition of soils, and especially *sub*soils, from widely distant portions of the State, derived from the same geological (Quaternary) stratum.

A word in regard to the "freaks and accidents" mentioned by Professor Johnson as liable to make sport of the devoted analyst. Undoubtedly such errors must be ultimately provided against by multiplication of analyses (not necessarily of the same acre, but of other corresponding specimens, in the sense mentioned above); and while questioning the efficiency of a bird or squirrel in vitiating a properly taken sample of soil, I must admit the disastrous consequences which might result if a dog, cow, or horse were similarly concerned. No specimen of "virgin soil" can, of course, be obtained where such animals usually do congregate. But, as a rule, it is not at all difficult to avoid such places; while the chance of accidentally hitting upon a sporadic animal deposit in the broad

woods or prairies is singularly small, and is notably diminished by the circumstance, that an attentive observer (and none other should take soil specimens) will be able to distinguish such localities for years, by the peculiarity of their vegetation.

I will remark, however, that I consider the sampling of a soil, with a view to securing a representative specimen, as a matter second in difficulty and delicacy only to the analysis itself; that I rarely have thought it worth while to analyze specimens sent by other than intelligent persons specially instructed by me; and even then have frequently had to reject them, from their having obviously been taken at an improper locality, *e.g.*, near a foot-path, by the side of a fence, on a partially denuded hillside or ravine, in the bed of a run, at the foot of a tree, &c.

The question of *depth* must, in my view, be left to be determined by the circumstances of each case, except in so far as the extreme depth to which tillage may cause the roots of crops to reach must be within the limits of the samples taken. Of these, *one* should ordinarily represent what, under the usual practice of tillage, becomes the arable soil; another, the subsoil not usually broken into; a third will in most cases be useful to show what materials would be reached were the land to be underdrained. As a rule, I have taken no specimens of soil to a less depth than six inches, and as much deeper as uniformity of color reached,— for obvious reasons. But in special cases, when important differences were suggested by the aspect of the soil and subsoil, they have been separately examined, at whatever depth the change of color might occur.

With soils of the character referred to, samples selected and taken with due care, and strict attention to thorough intermixture, both in the field and subsequently in the laboratory, I am unable to see why even two grammes may not correctly represent the characteristics of a thousand acre tract. Not that every point of that tract would be likely to give the same percentage result, perhaps; especially as regards the surface soil, which might in places be more clayey or more sandy than the sample analyzed. Still, the *relative proportions of the soil ingredients, and their degree of availability*, would remain substantially the same; the wider range and readier penetration of roots in sandier soils making up, within certain limits, for the smaller percentage of available ingredients in a given bulk, as compared with more clayey ones.

From the fact that the atmospheric surface water must, in its

course, inevitably have a tendency to bring about such inequalities, by carrying forward the finer particles of the soil in larger proportion than the coarser ones, as well as from the greater influence of vegetation, we shall, in the series of analyses made a postulate by Professor Johnson, expect to find a closer agreement between those of subsoils than those of surface soils. Such I find to be very decidedly the case; so much so, that I habitually look to the former as the most reliable index of a soil's distinctive character. To this there can be no legitimate objection, when, as in all the upland soils now under consideration, the surface soil is directly derived from the subsoil, and its depth is less than thorough culture would give to the arable soil.

As regards the analysis itself, I premise that I have always found even the most "chemically pure" reagents sold by dealers quite inapplicable to the purpose of soil analysis. From first to last, I have prepared or purified these myself; and, as regards the acids, especially hydrochloric, I have found it necessary to reject, as a rule, even the purest, after keeping it for a few weeks in a glass bottle. The same is true, and perhaps in an aggravated degree, of aqua ammoniæ. The severe ordeal of slow evaporation on a bright platinum foil will rarely be passed by ammonia a fortnight old; and still less frequently by hydro-sulphide of ammonium.

Armed with these, and a multitude of other precautions, usual and unusual, to secure the utmost possible accuracy; always treating the soil with the same large excess of acid of uniform strength, and precipitating all corresponding precipitates as much as possible from the same volume of liquid; using none but the best Bohemian glass, and platinum vessels, and filters specially extracted, — operating, in short, as uniformly as the nature of the materials would permit, I confess I felt considerable confidence in the correctness of my results, until the experiments made in Bunsen's laboratory, on the solubility of glass vessels, gave rise to unpleasant doubts. On consideration, however, I found that the (sensibly constant) error so introduced would not, when allowed for, amount to more than the differences between two analyses of one and the same material, or vitiate in any serious degree the conclusions arrived at. Nevertheless, I shall hereafter, to the utmost possible extent, carry on all operations liable to introduce errors on this score in platinum and porcelain vessels, as advised by Bunsen.

As regards Dr. Peter's failure to determine the amounts of sol-

uble silex, nitric acid, ammonia, chlorine, and the degree of oxidation of the iron, I agree that the former is desirable, not only because, whether "essential" or not, some plants do habitually absorb it in very large quantities, and it might be best to let them have it; but also because it is a desirable index of the degree of decomposition which the soil silicates have undergone. I have therefore made this determination regularly, by boiling with solution of sodium carbonate. In a series of these determinations, an unmistakable relation between the soluble silex and the amount of lime in the soil becomes manifest; as might, indeed, have been foreseen.

As regards nitric acid, the consideration suggested by Professor Johnson himself—viz., that its quantity must be exceedingly variable, within short periods, in one and the same soil—seems to me a sufficient dispensation from the laborious determination.

The same holds good, in a measure, for ammonia. Its quantity varies continually in the soil, as it does in the atmosphere; its chief absorbers in the soil are "humus" and clay. Where these prevail largely, ammonia can scarcely be deficient as a nutritive ingredient to an injurious extent; albeit, more might doubtless be beneficially added. Moreover, the characteristic effects of ammonia on vegetation are sufficiently obvious (in "running to weed") to render its determination in virgin soils, laborious and even uncertain as it is, a matter of comparatively little *practical* consequence, however great might be its theoretical interest.

As for the determination of the degree of oxidation of iron, I confess I fail to see its practical bearing. When ferric oxide is present, plants surely can have no difficulty in reducing the modicum they need to a soluble condition. When ferrous oxide exists to any great extent, it indicates a want of drainage, and manifests itself both in the color of the soil and in the poisonous effect on vegetation. But farmers surely do not need the aid of chemical analysis to tell them that their soil needs drainage and aëration! A determination made to-day would be of no value to-morrow, if the soil had been ploughed in the interval.

Finally, Dr. Peter *does* determine *chlorine*, in the treatment of soils with carbonated water; though it is not put down in the general analysis. However, the soluble chlorides, like the nitrates, are so constantly liable to variation and, as experience shows, so little likely to be deficient in the soil, that its omission would not be a serious practical objection.

A much graver defect is the failure to determine separately the organic matter ("humus") and the chemically combined water; and to this is owing, in a measure, the unsatisfactoriness of the analyses as regards information on the physical character of the soils. A large amount of water of hydration indicates, in ordinary cases, a correspondingly clayey soil, where heaviness in working may, or may not, be relieved by a large amount of "humus." The "volatile matter" item, however, gives us no information whatsoever on these vitally important points; and there is, unfortunately, no *simple* method by which the determinations in question can be effected even approximately. That they *should* form part of every soil analysis, is obvious, if only on account of the importance of "humus."

I have attempted to obtain a reliable scale of the different degrees of "heaviness" of soils, from the determination of their maximum absorption of hygroscopic moisture at ordinary temperatures. I find that at temperatures from about $+7°$ to $+21°$, the amount of aqueous vapor absorbed by a thin layer of soil exposed to a *saturated* atmosphere remains very nearly constant, being for—

Very sandy soils	1.5	to	2.0	per cent.
Loam soils	5.0	to	8.5	„
Clay soils, very heavy	12.0	to	15.0	„

there being, of course, all intermediate grades of hygroscopic power, as well as of "heaviness." It appears that, for this interval of temperature, the decrease of absolute absorbing power in the soil, resulting from the rise of temperature, is just balanced by the increased amount of vapor diffused in the air,—not an unimportant circumstance, with regard to vegetable life.

There are, however, two soil ingredients which interfere seriously with the correctness of the estimate as to "heaviness," derived from the coefficient of absorption, viz., "*humus*" and *ferric oxide*. Both of these are highly hygroscopic, yet both *counteract* the "heaviness" caused by excess of clay. Moreover, there is a class of soils (viz., fine silicious silts) whose exceeding "heaviness" in cultivation is much complained of, yet whose absorbent power is very small.

When, as in the majority of cases, the surface soil has been directly derived from the subsoil, the disturbing effect of the "humus" may be sensibly eliminated by comparing, not the soils,

but the subsoils, in this respect.* As to the ferric oxide, there are among about two hundred Mississippi soils analyzed but three or four whose agricultural qualities would have been seriously underestimated by a reliance upon the coefficient of absorption alone.

But I do not for a moment admit, that, in a material so complex both in its composition and mode of action, any one or few data, whether chemical, physical, or agricultural, may be relied upon to characterize the soil: or, as Professor Johnson expresses it, "to do violence to agriculture." So far from this, I consider that a proper interpretation of the analytical results must take into consideration, not only all the chemical and physical facts observed on the specimen, but all that has been or can be observed *in loco*, — the location, depth, derivation, relations to drainage, &c.; as well as all that is known concerning the qualities or peculiarities of the soil, both in its natural state and in cultivation. As Professor Johnson says, it should "form part of a system of observations and trials; must be a step in some research; must stand, not as an index to a barren fact, but as the revelator of fruitful ideas."

Such, precisely, has been my object from the beginning of my researches on the soils of Mississippi, for sixteen years past. Clearly, the difference between Professor Johnson's position and mine is one of degree only; yet this difference is not a slight one, since while, as before remarked, I have made, or caused to be made, some two hundred analyses of soils and subsoils, his classic works on the growth and nutrition of plants do not contain so much as a tabular exemplification of the composition of various soils, as resulting from chemical analysis. If, then, "the probabilities of its uselessness in direct application to practice are so great," as Professor Johnson seems to hold, I have committed a grievous error, and squandered the substance of the State.

I think that the considerations already adduced should plead measurably in extenuation of my course. But I will now state succinctly what services, in my view, soil analyses may fairly claim to be capable of performing, when conducted substantially in the manner, to the extent, and under the conditions defined above.

I take it for granted that, if in the determination of the mineral ingredients we were able to distinguish clearly from one another the portion immediately available to plants from that which is in

* In such cases, the surface soil is always more sandy than the subsoil.

an unavailable form, we should go far toward accomplishing what was originally claimed for soil analysis; and this Dr. Peter attempted to do by treatment of the soils with carbonated water. It cannot be doubted, however, that plants, as well as agriculturists, have at their disposal much more powerful, or at least more *energetic*, solvents; and that, therefore, a determination of those ingredients which may fairly be considered practically within the reach of agriculture must go deeper than does that with carbonated water.

Opinions may differ widely as to the proper strength and nature of the solvent (*Aufschliessungsmittel*) to be selected. Hydrofluoric acid, or ignition with the alkaline earths, would evidently go too far; as no soil, probably, will ever yield up the whole of its nutritive ingredients to plants, and fertility is far from being proportional to the *whole* amount of potash, phosphoric acid, &c., contained therein.

When, however, a *partial* solvent of uniform strength is used in all cases alike, and its action continued for the same length of time, it may fairly be presumed that, *as between soils of similar origin*, the amounts so rendered soluble are, in a measure, proportional to the amounts of available nutriment present.

In using hydrochloric acid of the strength 1.11 to 1.12 sp. gr., obtained by slow steam distillation of stronger or weaker acid, rejecting the first and last portions, I have in most cases found quite a satisfactory agreement between the results so obtained and the experience of cultivators as to the productiveness and duration of the respective soils; always *provided*, that the difference in the amounts of inert sand present, of specific gravity, of depth of soil, &c., were taken into account.

The proviso is important; but that with a proper local knowledge these allowances *can* be made, and that in most cases the information thus gained regarding the nature and treatment of the soil will be vastly more complete and reliable than the judgment of any number of "old intelligent farmers," my experience has fully convinced me: witness the egregious mistakes daily made by such in the selection of new lands. Moreover, a small minority only of farmers is likely to possess the requisite "age and intelligence;" and it is quite important that the multitude of those less fortunate should have the benefit of all the help science can give them.

I will adduce but one "odious example" of a widely prevalent

error in reference to the character of a class of soils, that I have as yet been unable to eradicate, even from among the "old and intelligent;" who are unfortunately very much given to theorizing on inadequate premises. Our prairie soils are notoriously limy; they are also very "sticky;" and the mud takes the hair off the feet of cattle. *Ergo*, every "sticky" clay soil in the State is called, considered, and treated as a "prairie" soil, especially if the hardened clods adhering above the hoofs of cattle should carry the hair with them. If such soil is unthrifty, and rusts cotton, it is because "there is too much lime in it," which "scalds" the seedlings. In matter of fact, most of these soils are notably deficient in lime, so as to be most directly and immediately benefited by its application wherever it has been tried, in accordance with my suggestion. The lime here acts, probably, as much chemically as physically; the clay being rich in potash, as per analysis.* While the physical defects of these soils are doubtless the main cause of the crop failures, yet analysis has suggested a remedy which relieves, for the time being, from the necessity of the more costly improvements; lime being comparatively easy of access.

Analogous cases are far from infrequent, both in this and in the adjoining States; and I have been led to attach special importance to the determination of *lime* in soils, from the (not unexpected) rule which seems to hold good very generally, viz., that, *cæteris paribus*, the *thriftiness* of a soil is sensibly dependent upon the amount of lime it contains; while, at the same time, in the usual mode of culture without return to the soil, the *duration* of fertility is correspondingly diminished, and its cessation is very abrupt wherever much lime is present.

It may be said that, after all, this is but what, from data already known, might have been expected. Granted; then, *à fortiori*, soil analysis, involving the determination of lime, is of considerable use in determining the present and future value of soils.

In speaking of the "amount" of lime, I must be understood to refer, not so much to its absolute percentage, as to its quantity in comparison with that of potash, which, with phosphoric acid, is what all our fertilizers chiefly aim to supply. Their determination must, of course, be considered of prime importance, since their absence or extreme scarcity is fatal to profitable fertility; while,

* See, for example, the article "Heavy Flatwoods Soil," in my Miss. Rep., 1860, pp. 276, 279.

when they are present, even though *immediately* available for absorption to a slight extent only, we possess in lime, ammonia, &c., and the fallow, ready and powerful means for correcting their chemical condition.

Here again the practical value of soil analysis is direct and indisputable. It is of no small interest to know whether the soil we intend to cultivate contains 75 per cent of potash and 25 of phosphoric acid, soluble in H Cl, or only the fifth or tenth part of these amounts. *One* will bear improvement of all kinds,—will pay for underdraining, terracing, &c.; while the other, quite similar in aspect perhaps, would not, according to Liebig's testimony, ordinarily be capable of profitable culture.

Again it is well known that the same species of plants may occupy soils of widely different quality and value. True, an attentive observer will in such cases see differences in the mode of development;* yet these are often such as to escape ordinary remark, and grievous disappointments frequently arise from this source, with new settlers especially. It is of no small importance to be able to *identify*, as well as to distinguish, soils resembling each other; and this, soil analysis can undoubtedly do, if there is any virtue in the law of probabilities even,—admitting all that may otherwise be said against their reliability.

Even if no other direct benefits than those already mentioned could be attained by the chemical and mechanical analysis of soils (which I do not admit, and expect to prove otherwise hereafter); even if we leave out of consideration the addition to our general knowledge which may fairly be expected to result from extensive series of such investigations, carried out upon a uniform plan, whereby accidental errors (whether caused by "birds or squirrels," or analytical and other mistakes) will be eliminated; even thus, I contend that the practical and theoretical value of soil analyses is sufficiently great to justify whatever labor and expenditure may be bestowed upon them by state and national surveys; and that the neglect with which this branch of research has of late been customarily treated is the more to be regretted, as no probable amount of private effort can accomplish what must, of necessity, be done on an extended scale, and with the *prestige*, voluntary assistance, and interest, not usually accorded to any but public enterprises. And with due deference to the author of the two volumes whose

* Miss Rep., 1860, p. 203.

extraordinary merits no one appreciates more than myself, I call upon my colleagues in State surveys, especially in the West and South, to reconsider this subject before it is too late, and a legislative fiat declares their work to be "finished." It is true that the agricultural colleges must and will take up and continue, as far as possible, the investigation of the agricultural peculiarities of each State; but the special and local experience acquired by those conducting a field survey, as well as their opportunities for extensive and comparative observation, are unfortunately "not transferable," even to the finest quarto report. In order to attain their highest degree of usefulness, our agricultural colleges should teach, not merely general principles, together with a sufficiency of the handicraft of agriculture; but they should be enabled to point out to each student, with reference to his particular neighborhood, How Crops Grow, and How Crops Feed.

III. PHYSICS OF THE GLOBE.

1. The Delta of the Mississippi; — the Physics of the River, the Control of its Floods, and the Redemption of the Alluvion. By Caleb G. Forshey, of New Orleans, Louisiana.

In the Delta of a river, we may properly embrace all the alluvial lands below the point where its first extravasated waters leave its banks, and may never return till they reach the ocean.

On the right bank of the Mississippi River, three miles below Cape Girardeau, in Missouri, the high waters escaped over the banks, prior to levees, passed into the White Water Lakes and swamps, connecting with the St. Francis and the Black Rivers, and thence down the White River and Arkansas Valleys, the Bayou Maçon, Washita, Red, and Atchafalaya Rivers, to the Gulf. These waters may never again, and often did (or do) never again, enter the Mississippi.

It is, therefore, proper to describe as the Delta all the alluvial lands on the Mississippi, and its affluents, below Cape Girardeau.*

This Delta,† according to my recently revised calculations, contains 38,706 square miles, including the alluvions of the several affluents below the point where their waters mingle. The confluent alluvions of the Arkansas and Red Rivers add respectively 500 and 1887 square miles to this great Delta valley.

Such is the fertility, such the climate, and such the productiveness of this body of land, that its rescue from submergence, by annual floods, becomes a matter of the highest moment to American wealth and civilization.

The subjects involved in this problem of reclamation embrace the Climatology and Physical Geography, the Geology and Physics, of the Mississippi Valley and River.

These must be reviewed in outline, in order to enter intelligently upon "The Control of the Floods of the River by Levees."

Climatology and Physical Geography.

The Delta extends across eight and a half degrees of latitude, from 29° to 38° 30′ north. It reaches from the semi-tropical land of the orange and lemon to the border of the ice-floes that, in

* In the year 1845, Sir Charles Lyell, the distinguished geologist, examined the Mississippi Delta and River. He had limited the Delta to the head of the Atchafalaya, and gave it an area of 13,600 square miles. He visited the writer, then residing at Vidalia, and busily engaged in writing a critique upon his chapter on the "Mississippi Valley," intended for his use. In this paper the head of the Delta was fixed at Cape Girardeau. Sir Charles insisted upon the completion of the essay; and he read it in my name before the British Association, and recognized my addition to his Delta. He has, however, in his recent edition, refixed the head of the Delta at the Atchafalaya (see "Principles," new edition).

† The swamps and lakes and sunken lands lying south-west from Cape Girardeau above the Crowly and Bloomfield Ridges, sweeping across the White Water Creek, the Castor, St. Francis, and the Black Rivers, are embraced in this Delta. In fact, all but about five miles wide for the Crowly and Bloomfield Ridges, which run down to Helena, — all else to the Black and White Rivers, below their junction, down to the Arkansas River basin, and taking a small portion of its valley. My line runs across to the sources of the Bartholomew, and down its valley, and that of the Ouachita, to Harrisonburg; thence around Catahoula Lake to Red River, up that to Bayou Rapides; thence down the Rapides — Bœuf, Cocoarie, Têche, and Vermillion — to the Gulf. Small areas of upland appear at various places, but nearly all is below the line of levels of the Mississippi at points opposite and east of this line.

rigorous winters, block the channel and arrest navigation of the river.

Its breadth in longitude has an average of one-tenth its length, being about sixty miles, though it contracts and expands from thirty miles in its narrowest width — as at Natchez and at Helena — to about ninety miles, as at Napoleon and at Manchac to Last Island.

The Delta is everywhere thridded and thwarted with interlocking bayous and navigable channels; placing every cultivable acre of its lands immediately upon, or very near to, steamboat navigation. In this particular it has no parallel known to civilized man. It is estimated that about one-tenth of the whole area is taken up in channels and water spaces; and yet such is their value and importance as to subtract nothing from, but rather to add largely to, the total value of its measured miles of land.

The fertility of the soils, both by analysis and experiment, is of the highest quality; in fact, it is almost inexhaustible. Accordingly, it produces, in its southern two degrees, the great staples of rice and sugar in abundance and perfection unknown in any other portion of North America. In fact, sugar is cultivated only in the Delta, and south of latitude 31° 30′. In nearly all portions of the Delta, but more thoroughly in the five degrees north from 31° (north of Red River), cotton grows in the Délta lands in double the quantities of the best uplands; and corn, and sweet and Irish potatoes, in every portion of the Delta, grow with facility and abundance, and with a minimum of cultivation. In the northern border the cereals grow and mature to the satisfaction of the agriculturist. The fruits of the tropical and temperate zones — oranges, figs, grapes, apples, and peaches — are duly distributed and easily grown, each in its proper habitat, over the Delta; while pecans, the most valuable of all nuts, grow in wild profusion over the entire alluvial basin.

The remarks as to productiveness are applicable to every acre not submerged, and not merely to chosen spots, as upon the uplands adjacent on either side.

We may compute then that 22,920,320 acres of actually productive land are upon this alluvial basin.* In this respect it is probably the largest body of like fertility known to geography.

* This is exclusive of 3,616 square miles of irreclaimable marsh, as will appear beyond.

The forests of the Delta are remarkable for the largeness of the trees, and the exuberance of foliage and vines.

The oaks and the cypress are the leading timber trees, though many others are used. The live oaks in the southern portion are large and very abundant, indicating mainly a soil not often inundated. But the cypress trees of vast height and magnitude, and of unlimited demand, grow best in the lowest swamps, and do greatly redeem and render equally valuable (as cultivable land) the most impracticable portions of the whole valley. Fifty thousand feet of lumber, clear stuff, from an acre of cypress swamp, is no unusual product.

So inviting is the temperature of this Delta, during the largest portion of the year, from the northern limit of the cotton region, south; and so promptly, uniformly, and abundantly do the soils respond to the labors of the husbandman, that its hundreds of winding streams were lined with settlers before the war, even anterior to any certain protection, by levees, from frequent inundation. It was common to say that a loss of two crops in ten, by overflow, could be better borne than the half crops produced upon the uplands.

Freedom from the extremes of heat and cold form a great feature of this Delta; and distinguish it greatly above the alluvions of the Nile, the Ganges, the Amazon, and the Orinoco.

The annual mean temperature at New Orleans, Bâton Rouge, Natchez, Vicksburg, Helena, Memphis, and Cairo, show a regular gradation from 69° to 45°.

The rainfall over the Delta, while it is abundant and well-distributed, has no extreme exceptions; but crops are invariably produced.

	Spring.	Summer.	Autumn.	Winter.	Annual Mean.
	Inches.	Inches.	Inches.	Inches.	Inches.
Memphis	11.0	7.5	7.9	15.0	41.8
Vicksburg . . .	11.0	12.0	10.5	16.7	50.9
Natchez	12.0	11.8	9.8	15.9	50.8
Bâton Rouge . .	18.5	18.4	12.2	15.0	60.4
Plaquemines . .	15.9	26.8	9.4	15.7	66.8
New Orleans . .	11.1	16.6	11.8	12.0	51.5 ?*
Mean. . .	12.4	15.4	10.8	15.0	53.5

* Some mistake appears in the figures for New Orleans. The rainfall is sixty-nine inches, I am convinced, by the scale, and by recollection.

In the lower portion of the Delta, bordering the Gulf, the marsh lands occupy 7232 square miles of area.

Of this portion of the Delta, about one half is reclaimable; the other half is irreclaimable, and would serve merely as reservoirs and water spaces, distributed through the reclaimed lands; thus reducing the reclaimable Delta to 35,813 miles.

Of the portion deemed reclaimable north of parallel 30°, about one-fifth is now occupied by man, mostly subject to occasional inundation from the river; the remaining four-fifths, or nearly 30,000 square miles, are utterly uninhabitable without the protection of levees against river and sea.

The water spaces, which occupy about one-tenth of the Delta, are so valuable to the habitable area, that no deduction should be made from the acres embraced in computing the value of the lands.

And in the computation of value over such a realm of fertility, by what measure shall we estimate it? Certainly dollars, or gold, in any form, will be inadequate to its measure. As well fix a value on freedom or civilization. To a nation or government like the United States, an area of this magnitude, lying for 600 miles across and along the borders of seven States, has no possible valuation estimable in money.

But when we consider that it will sustain a population of five millions of human beings, with nearly all the luxuries and all the comforts of life produced within the Delta itself; and that it will sustain double that number, or ten millions, with comforts and necessary wants, more profuse than in the denser populations of Europe, we approach an appreciation of the value of the Mississippi Delta, to the future demands of civilization.

Still as productions are measured, in the census tables, by dollars, and some approach to the capacity for production may be computed, we give the figures in a subsequent page, as some measure or index to the value of the Delta in the nation's wealth.

The Basin.

But the entire Delta lies beneath the level of the Mississippi's flood waters, as inferable from fact, so apparent in its geology, and from actual measurements across the basin or valley.

The great high waters are so numerous, and the ordinary high water so completely above the body of the cultivable lands in the Delta, that it were futile to attempt a general cultivation or

habitation of the alluvion without some effectual barrier against the floods.

The sections levelled across the Delta (see "Delta Survey"), and now carefully digested, reveal the result, that the average depth of the alluvial level, below the highest water-marks known, amounts to twelve and a half feet; and in obtaining this result the whole marsh region south of latitude 30° is excluded. The maximum depth is twenty-seven feet.

Hence, if unrestrained by levees, the floods of the Mississippi River would fill the alluvial basin, to the high-water marks of the river banks at corresponding latitudes, the alluvial sea would be six hundred miles long, and sixty miles in average width, and would have a mean depth of twelve feet six inches. It is therefore obvious that there would be no safety for life or property under such a contingency.

And although the flood might never acquire this maximum elevation, the records show that in the years 1809, 1811, 1813, 1815, 1823, 1828, 1836, 1844, 1847, 1849, 1850, 1851, 1858, 1859, 1862, 1865, 1868, and 1871,* the floods approached very near, within a few inches (less than half a foot at New Orleans, and less than two feet in the river the whole length of the Delta, where not recently disturbed by cut-offs), of the greatest high-water mark. And that mark is necessarily above the level of all the alluvial lands, lying opposite and south of each point of observation, on the river bank.

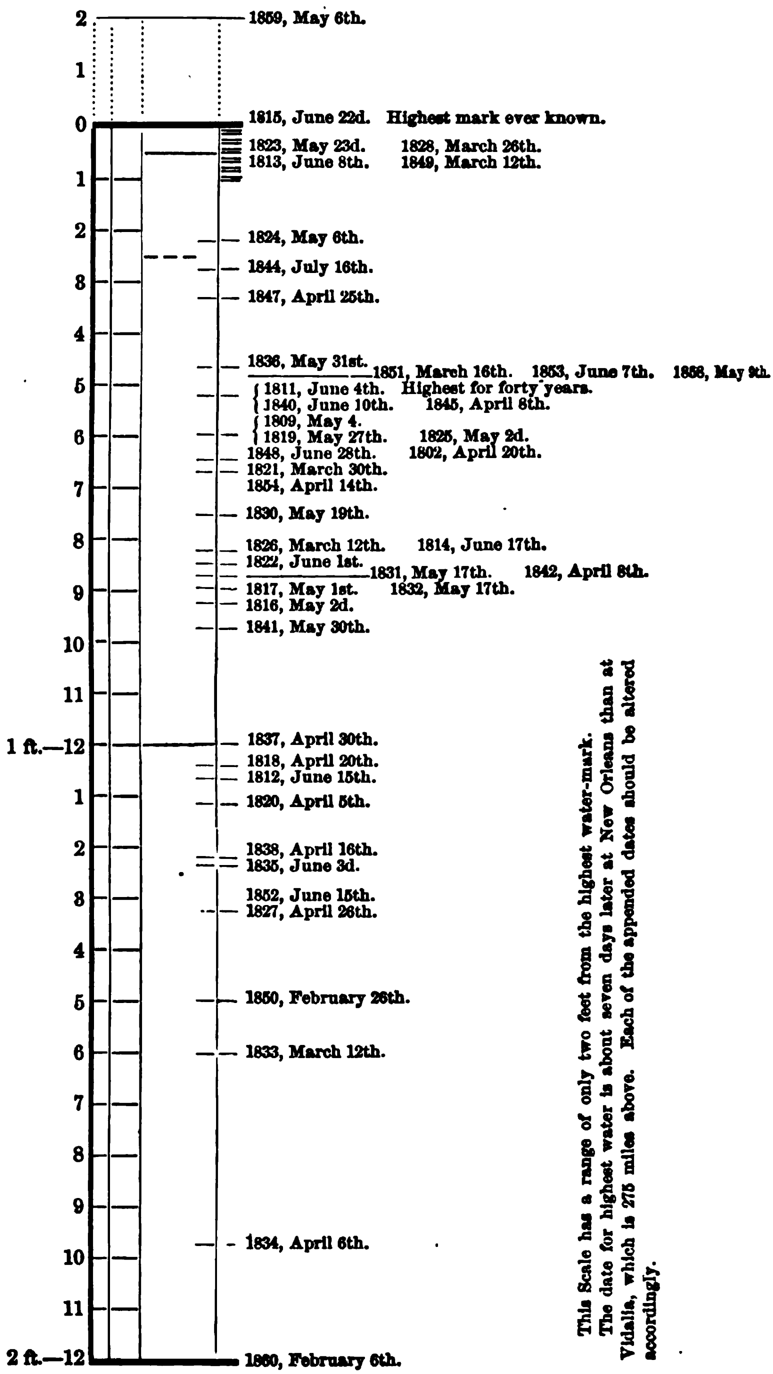
This isolated view will give some appreciation of the magnitude of the work for restraining these floods; for in all the seasons named prior to, and including, 1844, the main body of the Delta Valley was a fresh water turbid sea.

The following is a copy of original Scale, with Extension of Scale, and insertion of Water Marks and Dates since its production, to wit, from 1850 to 1872 inclusive. (*August* 11, 1872.)

* The high-water marks of the various years, as published by the writer, with diagram scale, in the "Concordia Intelligencer," in 1841, have been variously repeated since; and were published in the "Delta Survey" of Humphreys and Abbot, in 1860, with additions furnished by me up to 1850, and by the "Survey" to 1860 inclusive. It is herewith reproduced, with additions up to the present year, 1872.

TABLE OF HIGH WATER MARK, KEPT AT VIDALIA.

Published in the "Concordia Intelligencer," July, 1841, and August 3d, 1844. Reduced for the scale of New Orleans, and brought up to 1850. Registers of Governor Sargent, Samuel Davis, and C. G. Forshey.



This Scale has a range of only two feet from the highest water-mark. The date for highest water is about seven days later at New Orleans than at Vidalia, which is 275 miles above. Each of the appended dates should be altered accordingly.

Note 1.—Several years the highest mark did not reach this Scale, it was not within two feet of the highest mark.

Thus—1829, May 7th, the water was 2 ft. 1½ in. down.
1839, April 8th, „ „ 3 ft. 4 in. „
1846, June 1st, „ „ 3 ft. 0½ in. „

Note 2.—As Red River empties below Vidalia, these reductions would be subject to its modifications, as to date and altitude. Still this is the nearest approximation in my reach. C. G. F.

Carrolton, La., *January* 1, 1850.

Note 3.—1855, April 7th. Highest water-mark did not reach within 5.9 ft. of the highest mark of this Scale.

The question boldly put by the settlers upon the Mississippi's banks was this: "Shall man, or the waters, possess this realm of fertility?"

Their own answers were modestly made, in the presence of so sublime an enemy, by the rescue of small portions of land along the banks of the river proper. Small levees were thrown up in front of New Orleans, and the neighboring portions of the river banks.

Levee History.

The engineer who laid out the city (of one mile front from Canal Street to Esplanade) in the year 1717, De la Tour, directed a dike to be built in front, to protect the city or settlement from overflow. In 1728, the planters were constructing levees, each on his own front, for some thirty miles above.

Subsequently, the struggle was gradually maintained, the feeble attacking party growing stronger and stronger, without any hope or plan of general conquest, for one hundred years, till 1828.

The extent of levees then built reached nearly to Red River, and to Pointe à la Hache, in all about four hundred miles of levee. Still the struggle was individual, through the three changes of government. Lands were granted upon condition of levee construction in front, and thus the planter was left without systematic aid from government.

After the disastrous flood of 1828, the enterprise of the young State of Louisiana was aroused to the necessity of some joint effort, authorized and enforced by law, for the rescue of the front lands from inundation.

By the years 1836 and 1838, the first great outlets were closed: Bullet's Bayou, opening into Lake Concordia, and Bayou L'Argent, opening into Lake St. John (both in Concordia) a few miles above

Natchez. These were closed by parish enactment and tax, and not by riparian proprietors. And these two works mark the era of public levee history, undertaken with a view to a system for the reclamation of the entire alluvium.

Strong opposition was made to this attempt, and the two parties arrayed themselves for and against the closure of these outlets.*

The strong advocacy of *interest*, perhaps, rather than the bias of true science (for both were champions of the same cause), prevailed in favor of the continuous levees and closure of outlets. And one after another Bruin's Bayou, opening into Bruin's Lake; Alligator Bayou and River Styx, leading to Lake St. Joseph; Bayou Vidal, leading to Tensas; and Providence, leading to Lake Providence, were closed. So that by the great flood year, 1844, every Old River Lake, for six hundred miles up the right bank of the Mississippi, was effectually closed; and numerous as were the breaches in the levees, so newly and inadequately constructed, not one of the great levees closing these grand outlets gave way.

Such was the influence of the levees, north of Red River, on the general surface of the Tensas Basin, that the water-marks inside the Leveed Basin lacked an average of four feet of the level attained in 1828. At Trinity, General Liddel's, the difference was 5.6 inches. At Clark's Bayou, on Lake St. Joseph, the difference was four feet.

These results fortified and stimulated the advocates of levees, and confirmed the policy of closing outlets; and although nearly all the settlers on the interior streams were drowned out, their stock and much of their fencing swept away, they entered upon new and more elaborate efforts for perfecting and extending the levees on the front.

This struggle was continued under a desultory system of levees, built by parish authority, until the year 1853, when the swamp lands were made available for levee construction, and the strong arm of national aid was indirectly felt.

* As a young engineer, the writer stood upon the high bluffs at Natchez, in 1838, and looked down upon the Concordia plantations, and the vast Mississippi alluvion, and deemed it worthy the ambition of a hero in his profession to undertake its rescue. For two years he investigated the question of possibility. Then, in 1840, he espoused the levee cause, and wrote the first essay he ever read in favor of the complete closure of all outlets, and the leveeing and reclaiming the entire Delta; and to this day he has never faltered.

In the year 1849, the State Legislature of Louisiana had memorialized the Congress of the United States, praying for aid in the matter of protection against floods; and basing their argument for aid mainly upon the interest the General Government had in the unsold lands in the Delta.

The response made by the Congress was twofold. The Delta Survey was ordered to be made by the United States Engineers, and the swamp lands unsold were donated to the several States; so that by the year 1853, the several States interested had enacted laws relating to levees, contemplating the rescue of the entire Delta.

The survey ordered was undertaken, and for three years continued, and partial reports were made upon its progress; but the impression had been confirmed in the minds of the people, that the great Delta was made for the uses of man, and that a courageous people could rescue it.

So the progress of levee construction was right onward in spite of the diversity of jurisdiction, the want of uniform system, and the repeated crevasses caused by feeble levees, by accident, and by criminal violence.

In the year 1858, according to Humphreys and Abbot, the line of levees was complete on the left bank from Pointe à la Hache to Bâton Rouge; thence to Vicksburg they were not required, because the river impinges or approaches near the bluffs for this distance of two hundred miles. From Vicksburg to Horn Lake, the northern limit of the Mississippi, the line was completed, including a stupendous levee across the Yazoo Pass, the greatest outlet yet closed. Thence, to the head of the Delta, no levees were required, except very short ones for local convenience.

On the right bank, ascending, the line was complete through Louisiana, and up the Arkansas front to a few miles below the mouth of the Arkansas. Thence the banks of the Arkansas and Missouri fronts were well-nigh lined with levees, wherever they were required, to the head of the Delta at Cape Girardeau, the openings above the mouth of the St. Francis amounting to about twenty-five miles, and those below to about fifteen miles, — forty miles in all.

These openings were well-nigh closed, and the entire system greatly strengthened and improved by the beginning of the year 1861, when the war interfered and arrested all work upon the levees.

Physics of the Mississippi River.

The writer takes the liberty at this point to refer to his own labors, in the early years of investigation of the phenomena of this unexplored river.

In the year 1849, after eleven years of investigation, chiefly amateur, and while engaged mainly upon other professional labor, in reply to a call made by the Senate Committee on Levees of Louisiana, I prepared a "Memoir upon the Physics of the Mississippi," in which I collected and condensed, into a few diagrams and tables, the results of these labors; and wrote half a dozen brief pages of premises, principles, and conclusions; all of which were published as a public document; and the essay was put to sleep, with the oblivion predestined for State documents.

Having performed a large share of the labors of the Delta Survey — to secure which Survey my "Memoir" was contributed, with others of analogous kind — and having found my work very warmly acknowledged and commended in a most elaborate work (which will give immortality to its authors), I find sufficient merit in my original "Memoir" to reproduce a portion of its text; believing, as I do, that its main doctrines were affirmed by our subsequent most elaborate treatment of the same questions.

I think, further, that in its density it has the merit of a ready synopsis of the whole Physics of the Mississippi River.

In treating questions now relating to the practicability of the complete control of the flood waters, I believe its introduction here better than any thing new I could write or substitute.

I offer this explanation — no apology — for the resurrection of the Physics in this connection.

After collating and tabulating the observations and measurements of eleven years, I make the following *induction:* —

Application of Statistics and Principles.

Reasoning *à priori*, the following inductions and conclusions seem unavoidable: —

(*a*) The channel of the river is made by the abrasive force of its waters. A greater force would produce a greater channel, and a less force a less channel.

(*b*) The greater the channel for a given quantity of water and inclination, the less the liability to overflow.

(*c*) Concentration of force increases abrasive power, and diffusion of force reduces it.

(*d*) Levees confine and concentrate the waters, concentrate and increase the force, therefore increase the abrasion, therefore enlarge the capacity of the channel.

(*e*) Outlets diffuse the waters, reduce the abrasive force, and therefore reduce the capacity of the channel.

(*f*) If the channel be already greater than necessary for its servitudes, it would be safe to relieve it of some of its growing force by outlets.

(*g*) If the channel be too small for its servitudes, it would be wise to increase the channel-making power, by closing outlets.

18. The Mississippi River discharges a given quantity annually, and this is divided into daily supplies, with a maximum here in April and May. It can produce no more.

(*a*) If this supply be discharged with a greater velocity, it must maintain a lower level, even if the channel remain unchanged; for there can be no more than this quantity to be discharged, and hence the volume discharged within a month or year must remain the same.

(*b*) A greater force, with the same volume, implies a greater velocity.

(*c*) Therefore, the levees which confine the waters and concentrate the force increase the velocity and depress the level of discharge.

19. (*a*) From the year 1817 to 1827 there were no considerable levees above the mouth of Red River. From 1827 to 1837 the levees were being extended the whole length of Concordia coast, say two hundred and fifty miles; and from 1837 to 1847 we may regard the system of levees as in full operation for a long distance above and below the point of observation at Vidalia.

(*b*) During the first ten years (1817 to 1827) the mean height of the river's surface, for the year, was six inches above the mean height of the following ten years (1827 to 1837), while levees were being constructed; and nine inches higher than the mean height of ten years (1837 to 1847) under the levee system. This relates to the mean annual height, and is reduced to the range of Carrolton.

(*c*) But the mean high water-mark of these decennial periods is in like manner reduced, being 4.4 inches lower in the second than in the first period, and six inches lower in the third.

(*d*) But we have from the dates of highest water a very unexpected result; namely, the date of highest water is later in the second and third periods than in the first.

The mean dates of culmination are for Vidalia, April 26, April 30, and May 15, for the three periods, in their order; and the mean of the thirty years is on May 7.

(*e*) The common impression, that levees produce earlier high waters, would appear to be unfounded; and this is the conclusion which it seems to me would be arrived at, from section 18, *a*, *b*, *c*, because the supply cannot

be increased or hurried before the rains and thaws of the spring; and our levees can have little effect in hastening the dates of highest water at any point within the influence of levees. The mean dates of culmination, as given here, only prove to me that the periods observed are too short to obtain a fair mean, when the range is from March 12 to July 16.

Cut-offs. — By application of the principles and reasonings to facts we shall find: —

(*a*) That a cut-off shortens the channel, increases the declivity, accelerates the velocity, strengthens the channel-making power, abrades the banks and bottom with more vigor, and ultimately produces a lower mean level than before the cut-off.

(*b*) Accordingly, the effect of Shreve's cut-off, at the mouth of Red River, presented in 1844 these phenomena: — At the cut-off the water was three feet or more lower than the water-mark of 1828; twenty miles above it was thirty inches lower; forty miles up it was fourteen inches lower; at Vidalia, sixty miles above, it was seven and a half inches lower; and at Waterproof, ninety miles above, it was three inches lower; and at points above Waterproof it was regarded as equal to 1828.

(*c*) At Morganza it was eighteen inches lower, and at New Orleans and Carrolton full eight inches lower, than in 1828.

These facts were determined by myself at the time, and since; and carefully noted.

(*d*) We may conclude, hence, that the effect was perceptible about one hundred miles above, and at least two hundred miles below a cut-off, abridging the distance of current eighteen miles, and 3.54 feet to the fall of water, thence to the Gulf; and that it showed a reduction of high-water level both above and below the cut-off.

21. The Raccourci cut-off has been too recently made (1849) for a full illustration of the effects. Some have already been severely felt. It shortened the distance eighteen miles, with a fall at high water of 4.5 feet. The effects in draining the district above it have been realized as anticipated. Its effect at Vidalia was about 4.5 inches, and expired at a distance of about one hundred miles. Below, it has not had time to produce the new channel due to its acceleration, and has raised the water probably in a slight degree; but not to the mark of 1828 at Bayou Sarah by 2.5 inches. From the best information I can obtain, the difference is about two inches in the bend above Carrolton. By changing points of greatest force, and by increase of that force, it has committed great ravages upon the banks both above and below the cut-off. It will require but two or three years more, judging from past experience, to adapt the new channel to the new channel-maker, when the whole will be discharged at a lower level than before the cut-off.

22. The matter, as a question of hydrostatics, is settled, that a cut-off will reduce the level of discharge on both sides, and the question of policy be reduced to one of cost from abrasion of banks. This should be well weighed

before making a cut-off, from the suddenness with which a new force is applied. Levees are extended so gradually that the consequences are slow in being felt, and may be guarded against.

23. *Regimen of Rivers.* — It has recently been advanced by Dr. Riddell, "that the river has some normal regimen, and that the effects of a cut-off were to continue the caving in the bends of the river, until the channel shall obtain its former length, and regain its normal regimen."

(*a*) I am not aware of any law or laws of currents, whether sediment-bearing or clear, which will warrant such doctrine. *Inert matter can certainly have no choice of greater or less velocity.*

(*b*) The greater the momentum, of course the greater the power to remove obstacles; and all bends are obstacles.

(*c*) The weaker a fluent, the easier it is diverted from its course; and hence the tortuousness of streams with little fall.

(*d*) The aggregate tendency of a river with alluvial banks, of uniform power to resist abrasion, is to straighten its channel.

(*e*) No banks are uniform in this respect, and hence no stream attains or maintains a straight channel; but the power to approximate straightness is increased with the greater declivity, and increased force gained by a cut-off.

State of Levees and their Servitudes.

24. (*a*) The levees of Louisiana may be regarded as in full operation for fifty years, for a distance of one hundred miles from Bayou Lafourche down below the city. These levees have an average height no greater than those now being erected in the upper portion of the State; and the highest water-marks known, whether within the levee districts or not, are no higher than many points of the land; and some of the best river plantations present long reaches without levees.

(*b*) The river, therefore, has not raised its bed, nor reached a point of elevation, in recent years, greater than its level when it deposited its high grounds.

(*c*) To maintain levees in future, therefore, we shall have to raise them no higher than in the past.

25. (*a*) The location of levees below Bâton Rouge was chiefly made before those farther above, and consequently were placed too near the bank to admit of the new abrasions, arising from cut-offs, from extended levees, and from the never-ceasing steam-boat waves.

(*b*) For this reason they are now being destroyed by caving banks and by lashing waves.

(*c*) A period has arrived when these new elements have cut away the small battures; and the high waters, which the geology of this alluvion shows to have been frequent, geologically speaking, in past ages, are recurring, and our levees are wholly unequal to the task of restraining the waters. There are those who are not croakers that have foreseen these disasters; but their

warnings have not been heeded. *Good levees have not been erected.* The law in this respect has never been enforced.

26. (*a*) The management of levees has been in the hands of those least capable of enforcing the law. The districts have been determined by parish boundaries, and not, as they should be, *by the topography of the grounds.*

(*b*) The vigilant have often been inundated from the negligence of their neighbors.

(*c*) These considerations, and not any defect in the principle, have caused a distrust in the levee system.

What is the Remedy for Overflows.

27. (*a*) I would suggest to lay off the State into levee districts, indicated by the topography of the grounds, and of each district to make sub-districts in like manner, with guard levees running back between them.

(*b*) Let the districts be large enough to occupy the time, attention, and professional labor of a surveyor of levees. Let there be a chief engineer of levees, whose duty it shall be to survey and define these districts, and to nominate to the governor the district engineers, and to be responsible for their acts, and his own, in heavy bonds.

(*c*) Let the whole and sole control be placed in his hands, with plenary powers to enforce the law respecting work upon levees, and to draw from a fund created for that purpose, in order to have the work performed whenever the planter is delinquent.

(*d*) Let the levees be erected, in all cases, one arpent from the river; and two or three arpents whenever ascertained to be necessary, by a hydrographic survey of the river; the proprietor having to make such levees in front as may be desirable or necessary to his interest.*

Remarks on Extract.

In one or more items to which importance attaches, the learned authors, Humphreys and Abbot, have dissented from the proofs furnished that the plane of high-water discharge had not been elevated, but rather depressed, in the three decades furnished by me.

They present two additional decades: one of which does not accord with my conclusion; and the other does, most signally.

Their figures, undoubtedly correct, are, for mean high-water mark on the Carrolton gauge, five decades, from 1811 to 1860, inclusive: —

* Thus much from labors prior to the Delta Survey. "The Physics" was published in 1850, and received corrections till the paper went to press.

$\left.\begin{matrix}1811\\ \text{to}\\ 1820\end{matrix}\right\}14.65$; $\left.\begin{matrix}1821\\ \text{to}\\ 1830\end{matrix}\right\}14.68$; $\left.\begin{matrix}1831\\ \text{to}\\ 1840\end{matrix}\right\}14.18$; $\left.\begin{matrix}1841\\ \text{to}\\ 1850\end{matrix}\right\}14.78$; $\left.\begin{matrix}1851\\ \text{to}\\ 1860\end{matrix}\right\}13.87$.

Leaving out 1855, this last would read 14.20.

Why leave out any year? We should take the years as they come. Certainly I would not insist that there might not be a group of consecutive very high waters producing exceptions to this rule, as between 1840 and 1850; nor that such exception should not be in the opposite direction.

In fact, if my next group of ten years, 1848 to 1857, be taken, I am vindicated. With my learned critics, I agree that such illustrations only give probable, not demonstrative evidence; but I think their illustration unfortunate in not sustaining well their criticism.

Again, my proof that the river rises no higher now than prior to the construction of levees is based upon the fact, among many others, "that there are many points on the banks of the river where the natural surface of the land has never been overflowed within the memory of man," and certainly that the highest water-marks of the past fifty years have not risen materially above them.

This is termed a "fallacy" (p. 407) by the authors of the Delta Survey. And they proceed to show it by reference to the grounds about the Belleville Foundry, in Algiers.

By careful levels they find this natural surface .3 of a foot below the high water-mark of 1858.

Certainly it will not be insisted that a flood no deeper than .3 of a foot, or four inches, could have deposited the alluvial bed at the Belleville Foundry. In all probability the waters were one foot or more in depth for such deposits, judging from my great number of observations of this kind. True, I have seen alluvial deposit made in rapid currents, up near to the surface, but never in tranquil currents.

I must claim this illustration as definitely sustaining my view; *and this is demonstration*, not *probable evidence.*

Nor do I agree that "it is a sufficient answer to conclusions, based upon such facts, that there never has been a great flood since levees were built, without the occurrence of a large number of crevasses below Red River; and, consequently, that the volume of a flood has never passed New Orleans."

Certainly these able reasoners will not contend that at any

time the crevasses have been equal, in their outlet capacity, to the entire open banks of 244 miles!

I think they will, upon reflection, agree that in every concave bank there was one, two, or three miles of bank, about four feet below the flood level; amounting to some forty miles of such outlet, in addition to forty more miles of half the capacity.

Such were the banks unleveed above Red River in my first experience of floods. Prior to levee history, between Red River and New Orleans, I believe that the natural outlets exceeded all the crevasses by tenfold, even when you add the Plaquemine to their capacity. The river's bed at that period had no such capacity as at present, *me judice.*

Our experience in channel changes, since the recent great cut-offs, Raccourci, Palmyra, and Terrapin, seem to disprove the hypothesis that the river's bed is "very *tenacious* and *unabrasable.*"

The banks and the bed or bottom of the river easily and rapidly accommodate themselves to new forces, new servitudes.

I may insert a few diagrams of recent changes, prepared by General M. Jeff. Thompson, chief State Engineer of Louisiana, to illustrate his Annual Report, December, 1871. The dates attached render needless all comment upon the permanence of the Mississippi's bed; and leave the mind to its own inferences respecting the effects of the forces, gradually applied by the lateral restraints of levees, upon the bottom and the banks of the river in providing for the easy discharge of the waters.

The forces, formerly dispersed over the banks and expanded upon forests and thickets, are utilized in the *proper mission of river currents;* viz., *the business of channel-making.*

Delta Survey.

The final Report was made by the Engineer Department of the Delta Survey, planned by Colonel Stephen H. Long and Captain A. A. Humphreys, and conducted to its completion by the latter distinguished officer and engineer, and by his aid and coadjutor, Lieutenant H. L. Abbot, an able young officer.

This Report was so thorough and exhaustive as to leave nothing untouched; and the data were spread before the American public and before the scientific world, upon which to base a system of management and control of the floods, and to rescue the alluvium in accordance with the uninstructed ambition of the inhabitants.

The war between the "Outlet Advocates" and the "Thorough Levee Men" was decided by the Delta Survey in favor of the levee advocates; not wholly upon theory, but upon the impracticability of the outlet doctrine.

These officers, however, make one recommendation for an outlet, with many doubts and reservations; and locate it at Lake Providence, twenty miles south of the Arkansas line, right bank.

No one of the other points considered in the judgment of the writer was so impracticable as that recommended.

The Herculean efforts afterwards made by the army under General Grant to open an outlet, even for temporary uses, at that very point, and the utter failure to make it at all available, have disposed of this last stronghold of the outlet advocates.

Nothing remains, then, but *to put our trust in levees.*

Results of this Partial Reclamation.

Before the beginning of the war of secession, there had been constructed by Louisiana seven hundred and forty miles of levee on the Mississippi, at a cost of $18,000,000; and on the outlets, Atchafalaya, Plaquemine, and Lafourche, four hundred and forty miles, at a cost of $5,000,000; and in the Red River portion of the Delta, about fifty miles, at a cost of about $1,000,000; by the State of Arkansas, about one hundred and eighty miles, at a cost of $1,000,000; by Mississippi, about four hundred and forty-four miles, at a cost of $14,500,000; and by the State of Missouri, about one hundred and forty miles, at a cost of $1,640,000.

This is an aggregate of levee work done by the States and by the individual inhabitants, of two thousand miles, and at a cost of $41,140,000 spent in construction. And, in addition to this vast sum expended in a conflict of more than one hundred and fifty years, the loss of more than double this sum has been incurred in the disasters of crevasses and inundations; all wrung from the sweat of a most valiant industrial race, in the cause of reclamation and civilization.

Does it not seem, that this is a time for the government to step in and assume the protection of the area rescued from the dominion of the waters? Does not the laborer, in this conflict, the industrial soldier, whose ancestors for three or four generations have given their lives to this enterprise, deserve repose and laurels, for himself and his posterity.

But the saddest part of the levee history remains to be told!

No sooner had triumph been announced than desolation like a whirlwind came to this fair region, with its ten thousand plantations and its half a million inhabitants.

Wealth, refinement, lofty character, and a type of the most exalted civilization known to an agricultural people, were found on almost every stream, lake, and bayou in the Delta.

Such content, such absence of poverty, crime, and jealousy, such abundance of all the necessaries and luxuries of life, as prevailed among the planting population of Louisiana, Mississippi, and Arkansas on these Delta lands; and such an excess of production over consumption, in spite of the disasters from crevasses and inundations, it is believed, are unknown in modern history. In fact, it triumphantly vindicates and justifies the dreams of its most enthusiastic prognosticators of the early day.

But alas! the Civil War, with its bitter hostilities, came in 1861; and before one year had elapsed the tramp of armies, with fire, sword, and flood, was upon the people; and within two years these enormous works, that had cost such a century of toil, were cut down, *as a military necessity*, to overwhelm those who resisted the federal arms.

. . . .

The four years of the war left a desolation over these ten thousand fair fields, and an annual wilderness of waters, for several months each year, from the head of the Delta down to the marshes of the sea.

. . . .

Levee Labors since the War.

The amount of destruction to levees occasioned directly by military necessity, and the consequent abrasions and increase from the currents rushing through the openings thus made, can never be ascertained. Certain it is that long reaches of crevasse still remain unclosed; and that, especially in Missouri and Arkansas, little attempt has been made to replace them, above the mouth of the Arkansas.

The States of Louisiana and Mississippi immediately addressed themselves to the task of replacing the most important levees; and, although some great openings have been deferred on account of their magnitude, others of the largest kind have been rebuilt,

and again broken and rebuilt; and for the reason of extraordinary caving as a consequence of cut-offs newly made, and other causes, will have to be again rebuilt, for the third time since the war, to save the best plantations and some of the largest interests in the State.

The levees rebuilt since the war in Louisiana, in the four parishes north of Red River, and in Point Coupee, up to the end of the year 1870, amount to just 8,135,656 cubic yards at a cost of about $4,881,936.*

In consequence of the opening in the levee, at Ashton near the Arkansas line and at Diamond Island bend, the river did not rise as high in the district north of Red River as formerly, and the levees hence were built only to an elevation five feet below the highest water-marks; and hence the cost and contents have been greatly reduced.

General Thompson's Report of 1870–71, as chief State Engineer, says:—

In my October 26th Report, 1869, I have shown that it would require 5,218,000 cubic yards of earth to place the levees of these parishes in repair, up to the old grade. But the wear and tear of levees I estimate to amount to near 2,000,000 cubic yards per year. This year's report confirms last; for this report embraces every defective levee in the five districts, and calls for 5,111,300 cubic yards.

We have built 2,206,000 yards during this past season, which will leave 2,000,000 more for the Mississippi River, had there been no caving; but with new work just rendered necessary we shall require 4,000,000 yards, including the closure of the Ashton and Diamond Island crevasses.

O. D. Bragdon's "Facts and Figures for the People," January 1, 1872, prepared under the eye of the Governor by his private Secretary, and certified by the State Auditor, says, "The levee bonds issued by Louisiana, on which the State pays eight per cent interest, amount to $8,134,000." Thus:—

Act 35, 1865	$1,000,000
„ 15, 1867	4,000,000
„ 32, 1870	3,000,000
„ 105, 1870	134,000
	$8,134,000

* Flood's Report, of December 31, 1870, makes 4,533,250 cubic yards cost $2,608,666, giving an average rate of sixty cents per cubic yard (but see Bragdon's "Facts and Figures for the People," p. 42).

This is a strong comment upon the depreciation of State securities, when it requires $8,134,000, in bonds, to yield the $4,881,936 actually earned and paid out for the 8,135,656 cubic yards of levee built. Thus the system of building, under State management, and with State bonds, makes the cost *one dollar per cubic yard.*

The present contract with the Levee Company at sixty cents per yard requires the building of 15,000,000 yards in four years; upon which the State engages to pay ten per cent annually for twenty-one years, being entirely unable to pay the principal. In addition, the State contracts to pay a two-mill tax, for levee repairs. And this tax, and the ten per cent on the $9,000,000 for levee construction, are to be collected with the other State taxes on all the property of the State, for the twenty-one years of the contract.

Even with these apparently favorable terms, it was found very difficult to induce capitalists to undertake the task, from fear of the State's inability to comply with its contract.

Finally the burden was assumed by a few men of large means, whose whole fortunes lie beneath the levees, and who would be ruined if the levees are not maintained.

The estimated cubic yards of levees standing in the State in 1860 was as follows: *—

	Miles.	Cubic Yards.
From Arkansas line to Red River	250	15,000,000
From Red River to Fort Jackson	290	15,000,000
From Bâton Rouge to Fort St. Philip	200	9,000,000
Total on the Mississippi Banks		39,000,000

	Miles.	Cubic Yards.
On the Lafourche, both sides	70	3,500,000
On the Atchafalaya, both sides	70	3,000,000
On Red, Black, and Ouchita Rivers	200	5,000,000
Making a grand Total of		50,000,000

The amount of work done since the year 1865 is as follows:—

	Cubic Yards.
By the Duralde Board, cash contracts	4,674,414
By the Duralde Board, time contracts	2,495,800
By the Oglesby Board	362,350
By the Board of Public Works (Flood)	4,736,265
Total built since 1865	12,268,829

* General Thompson's estimate includes two years' levee building of the prosperous days after the Delta Survey, estimate given on pp. 18, 19.

Still required	5,111,000
Wear and tear for ten years, and the disaster of war inclusive	17,880,120

This was enhanced, too, by the forces of cut-offs.

The labors of the State of Mississippi, in restoring and strengthening her levees since the war, are not at this moment in reach, but are expected in time to furnish an abstract for this paper. The same may be said of the State of Missouri and Arkansas.

The Oppressive Tax of Levee Support.

These tables, estimates, and detail of labors, are presented to show how formidable is the undertaking to restore the broken levees, and how exhausting to the treasury of any single State to sustain the expense of the abrasive forces brought to bear upon the levees and the banks of the Mississippi River.

In the case of the State of Louisiana the resources for these purposes were wholly wanting. The State treasury was empty, and recourse was had to the issue of bonds for this and many other purposes, proper and improper; till the over-issue of obligations depreciated the paper, and made the expense of prosecuting these works of such vital importance extremely oppressive. In truth, such is the depreciation at the present time that bonds issued for any purposes are at half their face value. Her sister States of the Delta were no better provided with means for protection.

Impressed with the momentous importance of the levee protection, contemplating the fact that four-fifths of the property in the State was beneath the level of annual high waters, including the great commercial emporium of the Mississippi Valley, New Orleans, men of knowledge undertook the devising of a scheme which should transfer the business of levee protection to the care and interests of a powerful corporation.

After several years of discussion, and the sanction of the great commercial conventions, the Legislature of 1871 (February) passed an Act incorporating a company, and contracted with the same for the custody, construction, and repair of the State levees for a period of twenty-one years.

A provision of this Act binds the State annually to assess and collect, with other taxes of the State, the amounts to be paid to the Levee Company for their work, as stipulated; these sums

to be paid over annually to the Levee Company. Thus secured in their return revenues, a company of capitalists have entered upon the great work, and performed nearly one year's service.

The beneficial effects of this method have already been experienced in the complete protection of the State from inundation during one high-water season, by the judicious location and rapid and improved construction of about 2,500,000 cubic yards of levee.*

Such are the cormorant demands of the levee repairs and construction under the new servitudes of the river banks, that the taxation demanded to pay for the work done by the company will amount after the first three years to $1,400,000 per year!

This amount would be a very large sum for the whole State taxation. But when added to a State debt of indefinite millions, *whose interest must be paid*, the sum is more than the State can long endure; and bankruptcy stares her in the face.

Regarding these levees, however, as *vital*, it is probable this item will be borne, even if others utterly fail,—at least, during the period of the State's contract with the Levee Company, or till relief can be obtained.

But her people turn with the confidence inspired by a just cause, and ask of the Nation, the Federal Government, to consider whether they have not ample ground for respectful demand for entire relief from this stupendous burden.

Is not the enterprise of reclaiming the Delta *national*, in its scope and nature?

National Character of Levee Burden.

We have seen, in a previous chapter, the extent of the Delta covered by levees; and that the alluvial area fronts materially upon, and forms a large interest in, five States of the Valley of the Mississippi. And it is here proper to add, that it receives its contributions from no less than twenty-one States and five Territories,

* Fortunately for the safety of our many recently built earthworks, the river did not reach a very high mark, wanting three feet at New Orleans of the mark of 1858–71. But the water stood from five feet to twelve feet against several of the new works, constructed with the new improvements; yet *no seppage-water passed through the barrier provided against transpiration and burrowing animals.* The natural prejudices against new methods have been dissipated by the results of these tests.

destined soon to be States, and from an area of 1,256,050 * square miles. This basin of the Mississippi and tributaries receives from the clouds an amount of rain equal to 20.9 inches per year over the surface of the west or right-hand basin, and of 47.8 inches over the eastern or left-hand basin, including the upper Mississippi.

The total annual discharge of water upon this area, as computed in the Delta Survey, is 89,400,000,000,000 cubic feet. Of this quantity of rain, the discharge through the channel of the Mississippi into the Gulf is only twenty-five per cent, according to the elaborate investigations of the Delta Survey.†

This drainage bears with it the abraded sedimentary matters from every portion of the Valley; and in process of long ages has thrown the contributions down upon the Delta above described, and filled up the "inland sea," whatever may have been its actual extent and depth, till the alluvial area extends six hundred miles seaward from its head, at Cape Girardeau, to the bar at South-west Pass.

It is these contributions of transport material through which

* In my plea for a Geological Survey of Louisiana, 1840–41, addressed to Professor Riddell, and published in the "Commercial Bulletin," I computed the Basin of the Mississippi River at 1,300,000 square miles, and preserved the same in my critique upon Lyell, in 1845–46; and again repeated it in my chapter, "Geology of the Valley," prepared for "Monette's Physical Geography," completed, but never published. I waive to the Delta Survey, for courtesy, not for greater accuracy. A geodetic measurement would rather increase than diminish my figures.

† The subjoined Table, copied from p. 136 of that great work, is the result of the most searching and widely gathered statistics, digested and condensed as authority. It will be found convenient of reference, and is therefore presented.

Name of Basin.	Area. Sq. Miles.	Annual Rain. Cubic Feet.	Annual Discharge. Cubic Feet.	Ratio per ct.
Ohio	214,000	20,700,000,000,000	5,000,000,000,000	0.25
Missouri . . .	518,000	25,200,000,000,000	3,780,000,000,000	0.15
Upper Mississippi	169,000	13,800,000,000,000	3,300,000,000,000	0.24
Small tributaries	32,400	3,600,000,000,000	3,240,000,000,000	0.90
Ark. & White Rivers	189,000	13,000,000,000,000	2,000,000,000,000	0.15
Red River . . .	97,000	8,800,000,000,000	1,800,000,000,000	0.20
Yazoo	13,000	1,500,000,000,000	1,350,000,000,000	0.90
St. Francis. . .	10,000	1,100,000,000,000	9,990,000,000,000	0.90
Total, exclud'g Red	1,147,000	78,900,000,000,000	19,500,000,000,000	0.25

the river carves its channel, abrading and lifting the earths and soils from one place, and precipitating them in another, and gradually bearing its burden, partly suspended, but tenfold or an hundred-fold more "pushed" forward on the bottom, down the channel, and up the bar and over it, into the thousand-fathom depths of the Gulf.

When the time arrived for man to utilize and occupy the Delta, it became necessary to confine the waters and their transported materials to the channel, and hence to contribute them to the sea. The results as shown above, in the chapter from the Physics, are well understood; and the consequences, as shown in the Delta Survey, entirely manageable.

But *the new regimen of the flowing volume is greatly changed* and the *servitudes increased*, for a threefold reason: —

1. The increased forces during the high-water season, from the restraints by the levees.

2. The increased forces and changes of channel due to cut-offs.

3. The continued and ever-increasing forces thrown against the banks and the levees by the *steam-boat waves*.

Increased Force from Levees.

We have shown that this burden has grown beyond the control of the States.

Is the interest national from this point of view?

Certainly the Nation's wealth has been largely enhanced by the settlement, upon this Delta, of half a million of agriculturists, and the productions of the great staples of cotton, sugar, and rice, in such unexampled abundance.

The cotton produced in the alluvial basin in 1860 amounted to 688,254 bales or 275,301,600 pounds, worth at fifteen cents per pound $41,295,240.

The sugar produced in Louisiana in 1860 amounted to 460,000 hogsheads, or about 460,000,000 pounds, worth at seven cents per pound $32,200,000.

The rice, corn, potatoes, fruits and vegetables, and her stock, amount by rough estimate to ten millions more; an aggregate of $83,500,000.

"Restore Louisiana levees alone," says the Congressional Committee on Levees of 1871, "to their imperfect condition before the war, and we can make at least the 225,000 tons of sugar which were made in 1860. We consume

over 400,000 tons of raw sugars of all kinds; but the destruction of levees has sent us to Cuba and Brazil for this necessary of life. . We pay about $60,000,000 in gold annually for sugar and molasses over and above the ten or twelve millions in food, manufactures, and tools, which we export to those countries. If we produce at home these sugars, our mechanics get sale for the machinery and fine tools, and they take our sugars in exchange. The North and the West are interested in these sales. A very few more years of plantation extension would enable us to produce the whole additional demand, and to save yearly the sixty millions, and export largely to foreign countries."

The Committee continues:—

"Cotton is the great crop for export, and by cotton is controlled the exchange of the world. . . .

"In 1868, the crop in the United States, recovering from the disasters of the war by degrees, produced 2,430,893 bales; in 1869, 3,122,551 bales; in 1870, 4,352,317 bales; in 1871, a disastrous year, 3,750,000 bales. In 1861, Mississippi alone raised 1,202,507 bales, *more than one-third upon her alluvial lands.* In 1860, the Yazoo basin produced 220,000 bales.

"Complete our levees, and we rescue ten million acres of the best cotton land in the world; raise, besides other valuable staples, seven million bales yearly of this controlling staple. . . .

"For these lands are *level, and free from stones;* and, with a soil easily tilled, they are adapted to the use of all the improved agricultural machinery."

. . . .

The value of the lands embraced in the Delta, as forming an item of national wealth, becomes very important.

The area computed at 38,706 square miles contains, at six hundred and forty acres to each square mile, 24,771,840 acres.

What value shall we attach to these acres of more than Egyptian fertility? Let us analyze, before attaching definite values per acre, to this empire of wealth, or of water.

Assuming the 24,771,540 acres to have been worth unreclaimed $1.25 per acre on the front of the streams of the larger class, to the depth of one mile average on each side, amounting to about 10,000 sections or 6,400,000 acres, the value in money was, before levees, $8,000,000.

The remaining swamp lands would not have been bought in many years at ten cents per acre. These were the prices and condition of the lands above Red River, up to about 1840. The total value to the Treasury of the United States by this estimate was 8,000,000 + 1,477,184 = $9,477,184, as the total value of the Delta, six hundred miles long and sixty miles wide.

History tells us that in 1804 Napoleon I. sold Louisiana, embracing the Delta and an empire of area beyond it, to President Jefferson, for $6,000,000, when only an insignificant portion of the lands had passed into private hands. Let us ask what was the value of the Delta lands, at the beginning of the War of Secession, when our levees, feeble though many of them were, had been extended nearly the whole front of the Delta?

The lands completely reclaimed were worth $30 per acre; and these 6,400,000 acres, fronting on the navigable streams, were justly appraised at $192,000,000; and all the swamp lands not reclaimed for the plough were worth for their fuel and their timber, as appurtenant to the arable lands, $10 per acre, and had an aggregate value of $147,718,400; and the real value of the whole area of the Delta lands might be placed at $339,718,400. Levees raised this value from $9,000,000.

Should this reclamation be completed, in ten years, we are confident, the total value of both the cultivable and uncultivable areas of swamp lands would double this estimate. And in ten years from the completion of this work, the value of the landed estates, if at all estimable in money, would be $780,000,000.

What, then, would be the importance to the people of the United States in a period of fifty years, if all the alluvial lands in the Delta are reclaimed and utilized?

The amount required to put the levees in order, and to keep them at the grade indicated by Humphreys and Abbot in the Delta Survey, would appear trivial, and would be returned tenfold in a territory, rescued by science, courage, and enterprise from the former Delta Sea, the most valuable upon the surface of the globe!

Is not such a work NATIONAL?

New Servitudes from Cut-offs.

Four great cut-offs have been made since 1828; namely, the Shreve cut-off * at the mouth of Red River, three hundred miles

* A cut-off was made at Bunch's Bend, near and below the Arkansas State line, latitude 33°, in 1830. The length of the bend was about fifteen miles. There were no levees in that region at the date of the cut-off. The cut-offs below the mouth of the Arkansas (some six hundred and fifty miles from the sea), within a period recent enough to keep their "old river" lakes close to the present river channel, are worth attention. They are fourteen in number and about two hundred miles in length.

above the mouth, made in 1831, after the flood had subsided; and Raccourci cut-off of 1849, at a point only ten miles below the lower end of the Shreve cut-off. These shortened the river respectively eighteen and twenty-one miles.

The two cut-offs made above Red River were the Terrapin Neck of about twelve miles, made in 1868, at a point about thirty miles above Vicksburg, or four hundred and fifty miles above New Orleans; and Palmyra cut-off, twenty-three miles below Vicksburg, shortening the river about twenty miles, on this plane. This was made in 1867.

The total shortening of the river by these four cut-offs (all made within the levee period of their localities) is about seventy-one miles; and the plane of declination has been increased by some 8.4 feet, at the first two cut-offs, three hundred miles *from the mouth of the river*, and was increased about eight feet at the upper two cut-offs, some five hundred miles from the mouth. This increase of declination bears with it the consequence of increased abrasions on the bends of our river.

Such have been the immediate effects of these cut-offs as to cause great havoc upon the banks, near the cut-offs, both above and below; and to destroy plantations, and greatly increase the levee-making necessity. I again invite attention to the diagrams accompanying this paper for illustrations of these devastations.

These cut-offs can scarcely be charged to the people who live upon the lands, now demanding protection. They have been made both by natural and artificial causes: the natural, such as have made fifteen other cut-offs below Memphis, and above, between and below these enumerated; the artificial causes have all been personal and individual, except the single Raccourci made by authority of the Louisiana Legislature.

But, whatever the cause, the effects are upon us, and *must be provided for.*

It will be found below that the natural causes of cut-offs find a powerful auxiliary of the artificial kind, for which the commerce of the whole West and the Nation are responsible.

Certainly these new servitudes brought to bear upon the banks and levees are, as demonstrated above, beyond the ability of the people of the Delta to bear; and we, the people, turn with confidence to the General Government for relief.

New Servitude from Steamboat Waves.

The claim of the inhabitants of the Delta for national aid rests upon much stronger grounds than mere prospective revenues and productions. These claims come in the form of *reclamations*. They are based upon the perpetual and ever-increasing attack made upon the banks of the river and the levees, by the passing commerce of no less than twenty-one States and five Territories — the most productive of the Union — that send their untold commerce down the river, and receive their imports in return. The steamers that transport this commerce send their resistless waves against banks and levees, lashing and abrading them almost without cessation. Our lower river hardly ever rests. One set of waves succeeds another; and each finds its rest, in the equivalent of its forces, transferred to the banks and channel of the river.

These lashings and abradings, independent of the other causes, render the task of levee construction more and more oppressive yearly, until it has become intolerable.

Measure of Wave-Forces on Banks, &c.

Let it first be observed that the forces started by a steamer ploughing the waters are chiefly lateral. The bow of the vessel and the paddle-wheels throw up waves that cannot find movement, except along the surface; and even when the paddles strike downward, the displacement is lateral, except at very short distances beneath the dip of the wheel.

The force is felt downward only at the wheels or propeller; and these immediately react and run along the surface to the distant shores. And since the waters are indefinitely mobile among their particles, repose for displacement or violence can only be found against the walls of the channel. The total force exerted against the banks must be the same, whether diffused or concentrated, though the abrasions will be materially different.

Forces are never lost, though their facility of transmission is greatest in water, and least in solids, such as the river bank. And since these banks are composed of material brought and laid

down where they lie, by these very waters, moving at a velocity of three feet per second, whenever the new forces, brought to bear by *greater velocity* of wave or current, attack these particles, they displace them, and carry them down to lower levels.

Let us take an example.* The steamer "James Howard," of side-wheel construction, and with 1500 tons freight, passed up the river at near mean high-water gauge at Carrolton, 12.5 feet,—three feet below maximum. Her rate was about ten miles per hour against a current of four miles per hour, making a movement of her waves of 10 + 4 miles = 14 miles.

The waves of practical value were oblique, 23° to her course on each side, and could be distinctly counted to about the fifteenth wave; and I added five for the confused irregular waves that followed.

Ten of these waves were nearly of the same height, and were measured by their rise on a rod and a drift-log that did not break them.

These waves averaged about sixteen inches of height at three hundred feet behind the vessel; and the remaining ten waves averaged less than half that height, say six inches. They were all delivered against the banks with the velocity of the steamer, plus the rate of the current, say at fourteen miles per hour, or twenty feet per second.

Without attempting to weigh this force, by computing its dynamics from these data, I assume that the tonnage of the steamer, multiplied by her velocity,† gives the just practical result.

It is probable that the "Howard's" own tonnage is more than half her load, and that 2300 tons would be the weight of boat and cargo. We have then 4,600,000 lbs. delivered against the banks of the river, at the rate of ten miles per hour = 14.6 feet per second.

Now this force is repeated every length the vessel travels;

* I made a series of observations on steamboat waves for the Delta Survey, but do not find them in the Report. They were probably found too defective for use, and may not have been regarded as within the scope of the Survey. Nor are these, which I present, at all satisfactory. They may be in excess of the mean. I shall continue and exhaust the subject in my future labors.

† If the current velocity be added for an ascending boat, it must be subtracted for a boat descending. It is fair therefore to omit it in both, and leave the forces exerted by the lapse of the current, as a normal servitude, not involved in the new forces.

and taking her length at three hundred feet, or one hundred yards, the force is repeated 1760 times in every mile.

Thus the violence done to the banks and levees by one trip of the "James Howard" is measured by 4,600,000 lbs. $\times$ 14.6 $\times$ 1760, for each mile of her travel. The aggregate force then, that is abnormal, applied by this steamer, amounts, in foot pounds, to 118,201,600,000 lbs. = 60,000,000 tons, or 3,940,000 horse power.

These quantities are so enormous as to be unappreciable to the mind unless illustrated by some familiar example: —

A levee of nine feet in height, by our recent formula, say that of Humphreys and Abbot, with slopes of two and three to one, contains 1200 cubic yards in every hundred feet, and 3000 lbs. to the cubic yard. The three hundred feet of levee, equal to the length of the "James Howard," would weigh 10,800,000 lbs., and *the force thrown against the levee or bank, each trip*, by the passing boat, would be $\frac{68,160,000}{2} = 34,080,000$ lbs.; *more than three times the weight of the whole levee!*

Thanks to the tenacity of the soils and materials of the banks of the river, these banks *do* stand these forces, repeated fifty times a day under many modified forms; and still they stand almost miraculously this fearful servitude.

But this is wholly abnormal, and chargeable to the commerce of the Mississippi Valley.

Commerce of the Mississippi River.

It follows from the conclusions of the last pages, that the entire tonnage of the river must be aggregated, in order to make up the account of the levees against the Western country's commerce.

I am indebted to Judge W. M. Burwell, Secretary of the New Orleans Chamber of Commerce, for the items relating to this commerce woven into these remarks.

TABLE I

Arrived and Cleared at New Orleans, 1871.

River Crafts.	Trips.	Approx. Tonnage.
Steamboats	6344	160,000
Barges		10,000
Coastwise and Foreign Sailships	1041	150,000
Steamships	1094	60,000
Mississippi Barge Line, Eight Tugs and Forty Barges'		82,000
Other Barges on Mississippi and Ohio, exclusive of Coal		82,000
		444,000
Tonnage of Vessels		444,000

TABLE II.

Products Received.

		Tons.
Cotton	say 1,500,000 bales	375,000
Corn	say 4,000,000 bushels	121,000
Flour	1,571,281 barrels	186,000
Tobacco	25,000 hogsheads	28,000
Sugar (home crop)	140,000 „	154,000
Western Provisions other than Corn		50,000
Coal (5,000,000 tons per flat boats, — make no waves, float on the current)		
Other commodities, — Furniture, Lumber, Staves, Lathes, Hardware, Iron, &c.		86,000
		1,000,000

Imports, $20,000,000.

Estimated at one-fifth other receipts	250,000
Total Freights	1,250,000
Total Vessels	444,000
Total movement . . . Tons	1,694,000

Thus, the tonnage transported on the Mississippi in 1871, by *vessels producing waves*, amounts in aggregate to 1,694,000. Every ton and every pound of this freight sent its corresponding ton of wave against our banks, at an average velocity which, after some reflection, I have placed at six miles per hour = 8.8 feet per second.

To appreciate the effect of this prodigious force, we can but multiply the 1,794,000 tons by 8.8 feet per second, and impute a force of 15,787,000 tons running *currently* the entire line of our banks and levees of 2000 miles, *every consecutive point receiving this force!*

It is incredible then, that, in addition to the burdens the levees originally assumed, of current lapse and occasional wind-waves, the levees and banks of the Mississippi River should bear this servitude; and that the people who live along these river fronts should be able to bear the burden of rebuilding and repairing them for ever.

Certainly this burden should be now assumed by those whose commerce for ever attacks and batters them down.

No power but that of the General Government can reach a case so ramified, and touching the interests of people in so many States.

A subsidy from the national treasury, or some very small tax upon all the commerce that traverses the Delta through this river, and a like contribution from all the commerce and travel of railroads whose tracks and transportation cross or pass beneath the protection of these Delta levees, would be adequate to the burden of levee protection.

The cry for help comes up from a line of more than fifteen hundred miles of river front levees, and from more than five hundred additional miles required; from the millions who cultivate in their rear, or stand ready to enter the fertile fields; from the six great States of Louisiana, Mississippi, Arkansas, Missouri, Tennessee, and Kentucky.

The response should be loud and prompt from every producer or citizen of the Mississippi Valley and tributaries, in the form of substantial aid — by national legislation, or otherwise — to repair and build the walls of the channel of their untold commerce.

For, every barrel of flour or apples or potatoes, every sack of grain, every article of furniture, every plough, wagon, or engine, that travels down that river on its way to market, sends its continual wave to erode the Mississippi banks and levees.

The cause then is EMINENTLY NATIONAL; and to this great Nation we appeal, with confident expectation that its powerful arm, now released from all duties but those of peace, good-will, enlightenment, and civilization, will at once be extended to the rescue of the noblest area of fertility ever redeemed for the habitation of man.

In conclusion, it is due to this august body of *savants* to state frankly the motive for tendering, for their perusal and approbation, a paper which might be appropriately addressed to the Congress of the United States.

It is well understood by men of knowledge — and our country abounds with them — that the leaders of the advancing civilization of this age are found rather in the arenas of science than of politics.

I therefore appear before this tribunal for its sanction and approbation, from considerations of science and truth as well as for reasons of justice and national prosperity.

Tendering, then, my contribution, with becoming diffidence, to this greatest of human enterprises, I solicit for it a fair and impartial consideration before the Association and its august audience, — the reading, reflecting, and progressing men of the enlightened world.

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2. The Arctic Regions. Atmospheric Theory of an Ameliorated Climate and an Open Sea, in the Arctic Regions, in Opposition to the Gulf Stream Theory. By William W. Wheildon, of Boston, Massachusetts.

I. The Gulf Stream Theory.

Geographically the Arctic Regions are yet, as they have been for the last three hundred years, an object of great interest to the whole civilized world; and every thing relating to them, as an undeveloped and mysterious region, is sure to attract the public attention. All the resources of commerce and navigation, all the accomplishments of science, all the means at command of governments, and the very highest human powers, have been engaged in numerous efforts at exploration and discovery; and great results in science and geography have been their reward. Still the end and objects in view, in behalf of science, natural history, and

archæology, to say nothing of the interests of commerce, have not been reached: an immense region, full of life and interest, remains undeveloped and unknown. It is true that the continent of America, by the overlapping in the longitude of navigators, has been practically circumnavigated, and this has been accomplished through the great inside channels of the American Archipelago; but not so with the eastern continent, with Spitzbergen or Greenland. In the efforts that have been made to accomplish the complete exploration of these regions; in the attendant and contingent circumstances, sad and sorrowful as some of these have proved; in the known or supposed nature and character of the country, its deprivations and dangers, its teeming life and terrific natural phenomena — all of which contribute so largely to the desire to know more — to know all — is to be found that universal interest in the subject still manifested and still prosecuted by the most enlightened nations.

There are at the present time a number of expeditions, more or less efficient and complete, of public and private character, engaged, or soon to be engaged, in the exploration of the known and unknown regions around the north pole. Embracing, as these regions do, some five or six thousand millions of square miles of the earth's surface, including, it is supposed, an ocean of more than two thousand miles in diameter, it seems to be almost impossible that they should not make some important discoveries. Our interest as a nation in this subject is sensibly increased by the fact that a very large portion of what is now our national territory bounds upon the Arctic Ocean, and many points of historical interest in past efforts of exploration are within our extended boundaries. Possibly, and excepting for such legal interpretation as may result from the recognized international law of jurisdisdiction, our present boundary may reach to the north pole.

We had the privilege at the Meeting of the American Association for the Advancement of Science, at Newport, in 1860, of reading a short paper on the "Open Polar Sea," believed to exist in the vicinity of the theoretic pole. In this paper an attempt was made (1) to discredit the theory of the influence of the waters of the Gulf Stream in conveying, to the extent claimed if to any extent, the heat of the equatorial regions into the Polar Sea and the known phenomena which occur within the Arctic circle; and (2) to propose a theory believed to be more in con-

formity with attained results and admitted scientific principles and conclusions, than that already before the public. Perhaps it is true, however, that at the time referred to, when Lieutenant Maury, of the United States Navy, held an important scientific position under the government, and urged, mainly on assumed hypotheses, the influence of the waters of the Gulf Stream, no complete or adequate theory was intended to be set up; but it certainly is true that statements were hazarded and assertions made — since repeated and enlarged — not merely as if the Gulf Stream theory was one presented for consideration, but rather as if it had been fully established and received. These assertions, however authorized or seemingly authorized by facts, or sustained by arguments, went to show that the warm waters of the Gulf Stream reached the Polar Basin through Smith's Sound and the Spitzbergen Sea, in both cases as an under-current, beneath the cold water, and that, with a temperature far above that due to the latitude, it kept an open sea in the vicinity of the pole, and accounted for the various phenomena already referred to. These were the pretensions of the theory set forth by its advocates as though absolutely established, and spoken of as though universally admitted.

It is our purpose to show in this paper (1) that this theory of the Gulf Stream — and a similar one applied to the Kuro-Siow, or Japanese Current — is not sustained by such facts as we know, such evidence as is furnished by explorations, or such arguments upon assumed hypotheses as have been offered in its support; that if any of its waters do reach the Polar Basin they do not convey warmth or heat sufficient to keep an open sea in the vicinity of the pole, produce an ameliorated climate, or account for the varied phenomena of the Arctic Regions; and (2) that the atmosphere, by its well-known and admitted system of circulation, carrying heat and moisture from the equatorial regions to the poles of the earth, is adequate to the accomplishment of the objects indicated and is able to account for and explain the known meteorological phenomena of the Arctic Regions.

There can be no doubt of the circulation of the air generally as described, or of the circulation of the waters of the ocean; but it does not follow that the circulation of either can establish any rule or system for the other, and the fact referred to by Captain Bent, after Lieutenant Maury, that blood circulates in organic life or the air over and around the earth, proves nothing in regard to the circulation of the waters of the ocean. Each may have, and

doubtless does have, its particular system, as each has its particular laws, all subject to certain general laws, such as gravitation and the diurnal motion of the earth. So that, although the heated air of the tropics may reach the Polar Circle, it does not follow that the warm waters of the Gulf Stream do so, as the advocates of that theory seem to suppose. If we may reason from the movements of the waters of the ocean to the movements of the atmosphere, we may, with the same propriety and the same force, reason from the movements of the atmosphere to the movements of the waters, — so that, however this argument may illustrate the subject, it does not authorize any conclusion beyond the fact of circulation, and here the assumed argument of analogy terminates.

It is essential to our purpose to ascertain what we know of the Gulf Stream and the movements of its waters. Our most reliable knowledge of this stream, and nearly all that we know of it, is that obtained from the explorations, observations, and experiments carried on under the direction of the United States Coast Survey, and detailed in the thirteenth volume of the "Proceedings" of this Association. This information, of course, is more or less familiar to every scientific reader. The limits of these explorations, it is well known, are such as to leave the course of the Gulf Stream beyond longitude 40° west, at the farthest, wholly undetermined, so that its course, as a current, beyond that point remains uncertain and conjectural. Almost immediately after leaving the Straits of Florida, where the stream is only about forty miles wide, it bends to the eastward, between latitude 30° and latitude 40° increasing in width, so that on a line perpendicular to the latitude it is not less than five or six hundred miles wide. We may add that the statements of Dr. Bache, in the paper referred to, are confirmed by other authorities on the subject. Mr. Blunt expresses his belief that the Gulf Stream has no existence beyond the Western Islands, and that, *as a current*, it loses all its equatorial heat to the eastward of longitude 40°. Beyond this point, it is stated, the course of the stream has been partially ascertained by the drift of floating bottles, and also its presence has been traced much farther to the north by the warmth of the surface water, and its influence is felt in the climate of the north of Europe.

Lieutenant Maury, however, goes far beyond any explorations of the Coast Survey in regard to the Gulf Stream. Speaking

of the stream, "as far as the banks of Newfoundland" (latitude 46° 34′ to 51° 40′), he describes it as follows:—

After having run three thousand miles *toward the north* [?] it still preserves, even in winter, the heat of summer. With this temperature it crosses the 40° of north latitude, [then its course must have been *south* from Newfoundland,] and there [?] overflowing its liquid banks, it spreads out for thousands of square leagues over the cold waters around, and covers the ocean with a mantle of warmth that serves so much to mitigate in Europe the rigors of winter.

Here some authorities consider that the Gulf Stream ends. They describe it as "running in a north-east direction to about latitude 36° north (ten degrees south of Newfoundland), when it crosses the Atlantic, passes west of the Azores, and is lost in the ocean." But Lieutenant Maury, gathering it together again, proceeds in his description as follows:—

Moving now more slowly, but dispensing its genial influences more freely, it finally meets the British Islands. By these it is divided, one part going into the *Polar Basin* of Spitzbergen, the other entering the Bay of Biscay, but each with a warmth considerably above ocean temperature. Such an immense volume of heated water cannot fail to carry with it *beyond the seas* a mild and moist atmosphere. And this it is which so much softens climate *there.*

Lieutenant Maury also speaks of "an under-current setting from the Atlantic, through Davis's Straits, into the Arctic Ocean," as from the Gulf Stream, and also informs Lieutenant De Haven that "Wrangell's Polynia, to the north of Siberia, if it exist, probably owes its freedom from ice to the warm waters of the Gulf Stream, which run between Spitzbergen and the North Cape, into the Arctic Ocean."

This theory — if it be such — so absurd and inconsistent that it is difficult to speak of it, seems really to have been received and adopted by others, and, perhaps we may say, not examined by any one. Dr. Hayes, in the revised report of his lecture before the Smithsonian Institution, says, "The lecturer followed Lieutenant Maury in suggesting that this water receives its heat from the tropics, and as a deep sea current flows northward into the Arctic Basin." The theory has also recently been enlarged by Captain Silas Bent, of St. Louis, formerly an assistant under Lieutenant Maury, and has been applied by him to the Kuro-Siow, or Japanese Current. He thinks that these currents, prolonged to the pole, discharge their

heat, and "produce an open sea;" and that they constitute the only practicable avenues by which ships can reach it or the pole.

These several statements as to the course and influence of the Gulf Stream are conjectural and contradictory; and not long after some of them were made, in the interest of the proposed expedition of 1859–60, Dr. Bache, at the close of his lecture on the Gulf Stream before this Association, at Newport, declared that "the after-progress of this mighty Stream, and of its branches, if it does divide, *remains yet to be traced*, and so also its heading in the Gulf of Mexico." *

It is not impossible that the warm waters of the Gulf Stream may reach the coast of Norway, — most likely not as a current, — and enter the Arctic Circle, and peradventure "assault the ice-girdle that surrounds the Polar Sea," as Captain Bent supposes; but the supposition is by no means clearly established. Leaving the southern branch (if, as Dr. Bache says, "it does divide") to form the Sea of Sargasso, if that has any existence, or rejoin the equatorial current, the important question in this discussion is whether the waters of the Gulf Stream enter the Polar Basin, carrying their warmth into that remote sea, some three thousand miles distant from the point at which Lieutenant Maury says "it spreads out for thousands of square leagues over the cold waters around." To do this, it is asserted, two ways are open to it: one as a surface-current through the great ice-barrier, forming a "gateway" into the Polar Basin; and the other as an under-current, beneath the ice-girdle, coming to the surface again, giving out its heat and becoming cold water; and to these a third way may be added by following around Nova Zembla and the Asiatic coast towards Baron Wrangell's supposed Polynia, which was at one time a favorite theory.†

It is not too much to say that each of these ways has its difficulties, to say nothing here of the conjectural and contradictory statements made in regard to them. If we dismiss the third proposition, — which has little or no evidence to support it, — the other two stand to each other as the horns of a dilemma: they directly contradict each other; and the broader the ground of

* Proceedings, vol. xiii., 1861.

† "Wrangell's Polynia, to the north of Siberia, if it exist, probably owes its freedom from ice to the warm waters of the Gulf Stream, which run between Spitzbergen and the North Cape into the Arctic Ocean." — *Maury's Instructions to Lieutenant De Haven.*

argument in support of one, the broader the ground of objection to the other. They probably might be safely left to the full force of the facts, if there are any, and the reasoning of their respective advocates, whose statements we have quoted. Lieutenant Maury and Dr. Hayes seem finally to agree in support of the undercurrent theory, Captain Bent and perhaps Dr. Peterman to uphold the surface-current theory, but it is simply impossible to reconcile their statements with each other.

It is known that the Gulf Stream becomes so diffused and "spread out," and so lessened in its velocity, that it is doubtful if beyond a certain limit, long before any of its waters reach the coast of Norway, it can properly be called a current. We have already quoted Mr. Blunt's remark on this subject. He does not believe in a current or equatorial heat beyond longitude 40° west; and thinks the set of the sea to the east is that general to the North Atlantic, and the temperature of the water the general temperature of those regions. Lieutenant Maury says the stream loses 50° or 60° of temperature before it reaches the frozen regions: this will reduce it to about 25° (below the freezing point of salt water!), and of course it can neither go through the ice or beneath it, nor maintain Wrangell's Polynia. In the American Cyclopædia it is said, "When the Gulf Stream reaches the coasts of France, Spain, and Portugal, so expanded and so diminished is its velocity, that we must resort to the track of bottles thrown into the ocean, and afterwards picked up, to ascertain its course." If so ascertained, it may be simply the drift of the ocean, and not at all indicative of the Gulf Stream as a current. "In passing to the higher latitudes of the Arctic Seas," says Judge Daley, in his annual address before the New York Geographical Society, 1870, "it is so reduced and weakened that Admiral Irminger, of the Danish Navy, in 1853, between 61° and 63° of north latitude, and 14° 18′ west longitude, found that it ran during an observation of twenty days only at the rate of three and one-tenth nautical miles per day." It is doubtful if a drift of this nature should be called a stream or current; and the distance is more than a thousand miles from the ice-barrier, under which the stream is to pass or through which it is to melt its way, *in less than a year!*

Dr. Kane, believing in the evidence which points to the existence of a milder climate and an open sea near the pole, is not disposed "to express an opinion as to the influence which ocean currents may exert on the temperature of these far northern

regions," but asks "whether it may not be that the Gulf Stream, traced already to the coast of Nova Zembla, is deflected by that peninsula into the space around the Pole?" Perhaps so, if the premises were so; but Nova Zembla is an island, and as no authority is known for the statement that the Gulf Stream has ever been traced to that point, it seems probable that Dr. Kane meant Norway, which is a peninsula. Dr. Buist, however, makes the suggestion that most likely from the coast of Norway, if the stream really reaches that coast, it turns back to form a second great whirlpool, rejoining the original stream near Newfoundland. In this case it would probably join the polar current, passing along the east coast of Greenland, around Cape Farewell, up the west coast of Greenland as far as Cape York, and thence down the east coast of the United States and under the Gulf Stream through the Straits of Florida, — supposing it to be known that there is a current over the whole of this route. It is this current that supplies the natives of Greenland with drift-wood for fuel, and floats icebergs to the north as reported.

The suggestion of Dr. Buist would also seem to conform to the movement of the south branch of the Gulf Stream, as probably also to that of the Japanese Current in the North Pacific Ocean.

An argument has been advanced in favor of the Gulf Stream theory founded upon the experiments in the temperature of the water at the surface and at certain depths beneath it, made by Dr. Scoresby and others, in the Spitzbergen Sea. Dr. Scoresby's experiments were made between latitudes 78° and 80°, at points varying from thirteen to 761 fathoms, and indicate a gradual increase of temperature approximating the point of the greatest density of water, 39° 5′, the highest point reached being 38° at the depth of 761 fathoms, that being six degrees warmer than at the surface. These results appear to be confirmed by Captain Beechey's account of Captain Buchan's voyage to Spitzbergen, in 1818. In harbor at Magdalena Bay, in June and July, temperature at the surface and at thirty fathoms, 34°; at thirty-five fathoms, 34° 30′; at ninety-one fathoms, 36°; at 335 fathoms, 35°, or one degree warmer than at the surface; at 700 fathoms, 43°. But it does not appear that these observations have any relation to the Gulf Stream on the north-west of Spitzbergen or in Magdalena Bay. Some experiments of this kind were made by Commodore Rodgers, on the north-west coast of America, in 1855, in latitude 72°. He found at twenty fathoms depth, 35° 5′; at

forty fathoms, 40° 5′. In similar experiments by the Coast Survey, stated by Dr. Bache, ninety miles from Havana the following results were obtained: at 575 fathoms, 35°; 525 fathoms, 40°; 425 fathoms, 45°; 300 fathoms, 50°; fifty fathoms, 75°. Off Cape Florida, 1200 fathoms, 38°. We do not see that any thing is proved or indicated.

Dr. Buist, after remarking, "So soon as water is cooled down to 40°, it sinks to the bottom," says: "A striking fact has just been brought to light: there is a line extending from pole to pole, at or under the surface of the ocean, where an invariable temperature of 39° 5′ is maintained." The depth of this varies with the latitude: at the equator it is 7200 feet or 1200 fathoms. At latitude 56° it ascends to the surface, the temperature of the sea being here uniform throughout. North and south of this, the cold water is uppermost; and at latitude 70° the line of uniform temperature descends to 4500 feet or 750 fathoms. This statement is very suggestive, but needs further investigation.

We repeat that the evidence that the Gulf Stream does any thing more than "run *towards* the Spitzbergen Sea," covering the Atlantic Ocean "with a mantle of warmth that serves so much to mitigate in Europe the rigors of winter," as Lieutenant Maury says, is wanting; and that, if it is admitted that it strikes the coast of Norway, either above or below the Arctic Circle, that it most likely turns and joins what in fact is an outward current from the Arctic Basin. But suppose it reaches the coast of Norway, with its temperature reduced fifty or sixty degrees, and has then to pass round Nova Zembla and along the coast of Siberia in order to find Baron Wrangell's Polynia, *more than a hundred miles outside of the coast ice;* or to pass through the great ice-belt, or, what will be found quite as difficult, beneath several hundred miles of ice, how much above 29° will be its temperature when it reaches the vicinity of the pole or the open sea? It seems to us that there is no possibility for the waters of the Gulf Stream, as such, to enter the Polar Basin. But notwithstanding, if it should be allowed that these waters do reach the ice-belt and keep an open channel through it, or after passing beneath the ice have sufficient heat to keep an open sea around the pole,—improbable, if not impossible, as these admissions are,—they utterly fail in this case to afford any explanation of the warm winds and the great problems in the varied phenomena of the Arctic Regions, and their explanation must be sought for in some other direction.

But, after all the discussion and controversy on this subject, it seems quite possible, to say the least of it, that an open sea around the pole may exist without any aid from the Gulf Stream. Professor Agassiz said at Boston, in 1860, that "every thing seemed to indicate the existence of an open Polar Sea; if there is no land there, it is not probable that there is much ice." The words are full of meaning; and at the same time he remarked, "The existence of land in that quarter is counter-indicated." Dr. Hayes subsequently admitted, while relying upon the Gulf Stream waters to keep an open sea and support his general theory, that "it is not too much to say that so large a surface of water as the Arctic Ocean cannot be frozen over even during the winter. . . . All experience shows that it is only near the land that we find the Arctic waters completely closed." Dr. Rink, we believe, does not absolutely deny the existence of an open sea, which finds advocates among so many of the most eminent English explorers. His language expresses doubts of an open sea, "assumed to be kept open by a branch of the Gulf Stream, from Nova Zembla down Smith's Sound to Baffin's Bay;" but he probably will not deny that an open sea may exist without the assumption of such an influence in a space of waters "one-fifth greater than the Atlantic between Newfoundland and the Irish coast."*

So that, so far as an open sea is concerned, there is no absolute need of the waters of the Gulf Stream; and this long-questioned and disputed matter of an open sea, kept open by the influence of the Gulf Stream, appears to be settled or dissipated; and the argument, with those who still object to the open sea, must be, if continued, to show that an immense ocean — the most boisterous and turbulent on the globe — may be completely closed with ice of indefinite thickness; a matter which we think will not be attempted even in view of the long Arctic winter. It would seem from what has been said that the existence of an open sea, as an established fact, might be safely accepted, with or without atmospheric influence.

There is another influence generally attributed to the Gulf Stream, and of course intimately connected with this subject, of which we may very properly say a few words in this connection: it is the supposed direct influence of the stream upon the climate of Europe in high northern latitudes. Dr. Carpenter,

* Hon. Edward Everett, at Boston, 1860.

who is undoubtedly qualified to give an opinion on this subject, while allowing that the waters of the Gulf Stream flow towards the Arctic Regions in the direction of the Spitzbergen Sea, does not believe that they are an adequate cause of the well-known high temperature which prevails in the northern latitudes of Europe, — then, of course, not of the phenomena of the Arctic Regions, — but would probably accept the conclusions of Professor Agassiz, "that the temperature of the Gulf Stream, in connection with the temperature of the south-west winds blowing obliquely across the Atlantic, modifies that of the western coast of Europe," &c.* There is no doubt that the Gulf Stream modifies the temperature of the Atlantic Ocean, and warms the winds that blow over it; but Professor J. Muller finds "a second cause to which Europe owes its relatively warm climate in this, — that in the equatorial regions it is bounded towards the south, not by a sea, but by an extensive continent, Africa, whose vast extent of desert and sand renders it extremely hot where exposed to the vertical solar rays. A warm current of air rises continually from the glowing hot sandy wastes to descend again in Europe" † [or farther to the north].

Chiamisso, the naturalist, who accompanied Kotzebue in his expedition in 1815–18, develops his views by remarking that "when we extend our eyes over the globe it appears to us that the twofold current of the atmosphere from the equator to the poles, in its upper regions, and from the poles to the equator in the lower, must bring over Europe from the interior of Africa, which is scorched by the sun, a current of air far more heated in proportion than over any other country in the world." He considers the continent lying to the south and south-west of Europe, between the line and the northern tropic, as a furnace which heats the air that passes over it and determines its climate; and, in general, he thinks that continents lying between the equator and the tropics must give to the more eastern parts of the world towards the pole a warmer climate than other parts enjoy, though under the influence of seas similarly placed.

Thus, to account for the modified temperature of North-Western Europe and North-Western America, we have not alone the warm waters of the Gulf Stream and the Kuro-Siow, but the warm south

* Report on the Florida Reefs, Coast Survey, 1851.

† Principles of Physics and Meteorology, p. 515.

and south-west oceanic winds, and the influence of the heated air of the equatorial regions blowing over them.

In view of what has been said we make the following conclusions: —

1. That the course of the Gulf Stream beyond the point indicated, about longitude 70° west, is unknown and uncertain.

2. That if it reaches the Spitzbergen Sea, it is much weakened as a current and too much reduced in temperature to have any appreciable effect either upon the air or the water.

3. That if it touches the coast of Norway between latitudes 58° and 71°, or Nova Zembla between 71° and 76°, it turns back and joins the polar current or is lost.

4. That it does not enter the open sea around the pole; or if any of its waters do so, either through the ice-belt or beneath it, they are not of a temperature sufficient to keep an open sea or account for the meteorological phenomena of the region.

Note.—The most recent advices from the Spitzbergen Sea, communicated to the public by Dr. Peterman, make it quite clear that the space between Spitzbergen and Nova Zembla is the great outlet of the Polar Ocean. "In July and August, of this summer" (1872), he writes, "the ice-current held a more easterly course towards Nova Zembla, and left the western half of the sea free from ice."

II. The Atmospheric Theory.

The second branch of our subject is contained in the proposition that the atmosphere, by means of the well-known system of circulation from the equatorial regions to the poles of the earth, conveying heat and moisture, has the effect to ameliorate the rigors of the climate in their vicinity; and specially in regard to the Arctic Regions, maintains an open sea in the Polar Basin, and produces and explains on scientific principles the varied phenomena constantly observed in those high latitudes.

The System of Circulation.

The system of circulation is stated by Dr. Buist as follows: —

As the constant exposure of the equatorial regions of the earth to the sun must necessarily engender a vast amount of heat, and as his absence from the Polar Regions must in like manner promote an infinite accumulation of cold, to fit the entire earth for a habitation to similar races of beings a constant interchange and communion betwixt the heat of the one and the cold of the other must be carried on. The air, heated near the equator by the overpowering influences of the sun, is expanded and lightened: it ascends into upper space, leaving a partial vacuum at the surface to be supplied from the regions adjoining. Two currents from the poles towards the equator are thus established at the surface; while the sublimated air, diffusing itself by its mobility, flows in the upper regions of space from the equator towards the poles. Two vast whirlpools are thus established, constantly carrying away the heat from the torrid towards the icy regions, and thus becoming cold by contact with the ice carry back their gelid freight to refresh the torrid zone.

It must not be understood, we think, that the rising of the heated air from the surface of the earth is confined to the equatorial regions. The same thing takes place, no doubt, indefinitely north and south of the equatorial space; and in fact, wherever the air in contact with the surface of the earth becomes heated, it rises in the atmosphere, producing cloud, rain, &c., under favoring conditions, according to the theory of Professor Espy, — rising of course to lesser heights than the warmer air of the torrid zone. A paper in the American Cyclopædia also indorses "the general higher current all the way from the equator to either pole." Sir John Richardson says, "Aerial and marine currents operate in both [Arctic and Antarctic Regions] in modifying the climate." Dr. Franklin, when speaking of the presence of electricity in the Polar Regions, says it is brought "by the clouds which are condensed there and fall in snow." Mr. Bradley, of Jersey City, in the nineteenth volume of the "Proceedings" of this Association, says, "In the tropical regions where evaporation is most abundant, there is an upward current which carries the vapor to a great height, and then setting out both north and south constitutes tropical currents, which descend in proportion as they reach the higher latitudes. On reaching a region sufficiently cold, precipitation of snow or ice in some other form [?] takes place," &c. Lieutenant Maury declares that "*air* and water are the great agents of the sun in distributing his heat over the surface of the globe, cooling this climate and tempering that."

It is not strange, perhaps, that we should sometimes mistake

the services of one for that of the other; but in reference to the phenomena of the Arctic Regions the error we charge is that the agency of the air has been almost altogether overlooked, when, as we think, the evidence shows that it is the chief agency employed in modifying the rigors of the Arctic climate.

Without extending authorities on this branch of the subject, — the circulation of the air, — we may append to the statements already made a brief extract from one of Professor Ennis's papers on latent heat, in the last volume of the "Proceedings" of this Association: —

> When the heated air at the equator rises up, it ascends to the top of the atmosphere, according to the generally received doctrine, and rapidly passes to higher latitudes, when it falls and returns to the equator. But, when at the top of the atmosphere, its temperature must be lowered to correspond with all Marsh's figures of latent heat; and when the same air descends to the earth's surface in higher latitudes, its latent heat raises the extremely low temperature until the amount of sensible heat is the same again as it was at the equator, minus what was lost by radiation into interstellar space.

In view of this circulation of the atmosphere, as stated by different authorities, it would appear that the air of the equatorial regions, rising to the upper regions of the atmosphere, follows, with more or less variation by reason of the diurnal motion of the earth, the lines of longitude, converging at the poles with varying temperature, varying proportions of moisture, and consequently with varying force. The effects and consequences of this intermingling must be manifested in the formation of clouds; in violent and contending winds; in frequent calms and almost constant fogs; in the falling of snow and rain in large quantities, and evolving large amounts of latent heat; and in various other phenomena, such as mirage, mock suns, sudden changes of wind and temperature, &c.

Warm Northerly Winds.

One of the most common and remarkable of the Arctic phenomena is that of the warm winds generally from the north, which have hitherto confounded both observers and theorists; and so far it is believed, excepting in the paper presented at Newport, in 1860, remained unexplained and unaccounted for. Sir Edward Parry found at Melville Island, Winter Harbor, that the north

winds were often warm. The same fact was noted by Dr. Kane, at Van Rensellaer Harbor, where the summer winds from the north often brought warm and foggy weather. "The direction of the warmer winds points towards Spitzbergen Sea [across Greenland] and the relative colder winds come in a direction from the northernmost part of continental America." Mr. Schott says, "The direction points across Washington Land and Kennedy Channel;" and he adds, from the records of Dr. Kane, "It was found that winds generally tend to elevate and calms depress the temperature." Dr. Hooker (Transactions Linnæan Society, 1860) says, "It is a well-known fact that the temperature always rises rapidly with the north (as well as other) winds over all the Arctic American area." Captain Belcher says, "Of gales I take no special notice, but here they invariably accompany any undue rise of the temperature,"—rather perhaps produce it. At Unalachlect, Norton Sound, Alaska, Mr. F. Whymper says, "During a portion of the time passed at this place, we had extremely bad weather, with strong north and north-east winds. The thermometer invariably rose during the prevalence of wind: it stood at points ranging between + 7° and + 32° during our stay." Dr. Kane says, "That strange phonomenon, the warm south and south-east [north and north-east] winds, which came upon us in January, did not pass away till the middle of this month [February]. *There is much to be studied in these atmospheric changes.*"

It is not necessary to multiply these authorities: the fact of warm north winds around the whole Arctic Circle, in Siberia as well as Greenland, is well known; and, whatever the conditions or circumstances, are wholly inexplicable on the Gulf Stream theory.

It seems to have been supposed, and the assumption is still supported by the advocates of the Gulf Stream theory, that if an open sea can be established in the manner suggested by them,—or open water, as its equivalent,—all the phenomena of the Arctic Regions may be explained by that fact; but it will probably appear that this is a great mistake. Open water, which has been seen by explorers in all parts of the Arctic Regions, in many cases remote from any possible influence of the Gulf Stream, proves absolutely nothing beyond its own existence, which remains to be accounted for. Dr. Kane, however, ignores the argument by remarking that, to refer the phenomena to the presence

of open water, only changes the question; and the inquiry must be, "What is the cause of the open water?" Dr. Hayes, who has uniformly advocated the Gulf Stream theory and followed the lead of Lieutenant Maury, has heretofore relied upon the presence of open water, when it could be reached and pressed into the service, for every thing which he could not comprehend, almost it would seem without seeking any other cause. His experience, however, in 1860, in recording the temperature while frozen up in winter quarters, which gave him from the upper deck "a worse than tropic shower," compelled him to make the following statements: —

1860, November 13. — Worse and worse. The temperature has risen again, and the roof over the upper deck gives us once more a worse than tropic shower.

He then states that "the snow next the ice is more sloshy," and gives the temperatures as follows: at the surface of the snow, 19°; two feet below, 20°; snow in contact with the ice, 18°; water, 29°. So that no presence of open water at 29° could have produced the showers. Again, —

November 14. — The wind has been blowing for nearly twenty-four hours from the north-east, and yet the temperature holds as before. . . . I HAVE DONE WITH SPECULATION. A warm wind from the *mer de glace*, and this boundless reservoir of Greenland frost, *makes michief with my theories*, as facts have heretofore done with the theories of wiser men. As long as the wind came from the sea I could find *some excuse* for the unseasonable warmth (p. 182).

At this time Dr. Hayes was frozen in and surrounded by hundreds of miles of ice, and the wind was blowing towards an open water space in the south.

With his speculations thwarted and mischief played with his theories, Dr. Hayes still adhered to the eminent fallacy of open water, and believed he could find some *excuse* for his belief as long as the wind came from the sea, which in this case was blowing towards it. In a similar case to this, when Captain McClintock was confounded by the "unseasonable warmth," and found his "upper deck sloppy," he exclaimed: —

How is it that the south-east wind (north-east true) has brought us such a very high temperature? Even if it traversed an unfrozen sea, it could not have derived from thence a higher temperature than 29°. Has it swept across Greenland, — that vast superficies partly enveloped in glacier,

partly in snow? No! it must have been borne in the higher regions of the atmosphere from the far south, in order to mitigate the severity of this northern climate.*

But we have not mentioned all the experience of Dr. Hayes in 1860, for before the end of November, in that year, he found his theories still more severely tried, as he relates in the following extracts: —

The temperature had been strangely mild, a circumstance at least in part accounted for by the open water; and to this same cause was no doubt due the great disturbance of the air and the frequency of the gales.

We pass over this reference to open water again, as a *cause*, with the remark that Captain McClintock found a much truer one in his case, if in fact Dr. Hayes does not furnish a truer one in his own case as he proceeds with his record: —

I have mentioned in the last chapter a very remarkable rise in the thermometer, which occurred early in November; but a still greater elevation of temperature followed a few weeks later, reaching as high as 32°, and sinking back to 15° below zero, almost as suddenly as it had risen.† In consequence of this extraordinary and unaccountable [?] event, the thaw was renewed, and our former discomfort, arising from the dampness on the deck and in our quarters, was experienced in an aggravated degree. During two days [November 28 and 29] we could use no other fire than was necessary for the preparation of our meals and for melting our necessary supply of water. To add to our astonishment, *a heavy fall of snow was followed by a shower of rain*, a circumstance which I had not previously witnessed in this latitude, except in the months of July and August, and then scarcely more rain fell than on the present occasion.

The depth of snow precipitated during this period was likewise remarkable, — the aggregate being thirty-two (32) inches. In one single day nineteen (19) inches were deposited; greater by five inches than the entire accumulation of the month in 1853–4 at Van Rensellaer Harbor. The total amount of snow which had fallen up to the 1st of December was forty-eight (48) inches. Being so far north of the line of maximum snow, I was the more surprised, as my former experience appeared to have shown that the region of Smith's Sound was almost wholly free from nubilous deposits. (Hayes, pp. 193, 194.)‡

* McClintock, pp. 63, 64.

† In Captain McClintock's case the temperature of the air rose to 32° and fell back to 7° below zero, which of course is inexplicable on the open water hypothesis.

‡ "The difference between the observed and mean temperature of all hours during which snow (or rain) fell were likewise made out for each month of the

We have made these quotations from Dr. Hayes, partly for the reason that they are the most recent. His experience as here recorded is in several respects similar to that of other explorers in the Arctic Regions, many of them at a different season of the year; for it must be borne in mind that passing the winter in the vicinity of 80° north latitude is a modern experience, at least among navigators. Captain Ross mentions the fact of rain following a fall of snow at least three times in 1818; but these were in July and August, in which months, it seems, Dr. Hayes had witnessed the same phenomena, so far as we remember without recording them.

A very remarkable case, not however without its parallel, is reported by Captain Beechey, as follows: —

> On the 26th [June, 1818] we had a fall of snow, and at noon, for the first time since crossing the Arctic Circle, a shower of rain, which although the summer was so far advanced covered every rope in ice as it fell.

In this case the temperature of the falling water, and of course the region of the atmosphere from which it fell, was higher than the temperature of the air at the surface of the sea. This is of very common occurrence in the northerly portions of the temperate zone, and through New England, when the trees are covered with ice, presenting one of the most brilliant scenes of a New England winter.

Dr. Hartwig, in the "Polar World," page 27, speaks of the warm wind and rain as follows: —

> Even in the depth of a Siberian winter, a sudden change of wind is able to raise the thermometer from a mercury-congealing cold to a temperature above the freezing point of water; and a warm wind has been known to cause rain to fall in Spitzbergen in the month of January.

But the experience of Captain Parry, in his great sledge expedition in 1827, particularly referred to in a former paper, is yet to

year. These hours are warmer on the average, in the winter months, by 18°, than the corresponding mean temperature, the numbers decreasing regularly from winter to summer, and reversing in June to — 1°. On the average during the year, the sensible heat during precipitation was 7° 7′." — Charles A. Schott, Proc. Am. Ass., vol. xiii. p. 269.

In the circumstances detailed by Dr. Hayes, with such a remarkable fall of snow the "sensible heat during precipitation" must have been *very largely above the average*.

be mentioned. He experienced frequent changes from snow to rain of the most significant character. On the 3d of July, after recording rains almost every day, when in latitude 82° 3′ 19″, he says the snow had changed to a heavy rain, and had produced even greater effect than the sun in softening the ice. On the next day he was again annoyed by a heavy rain, the thermometers in the shade marking 35° and 36°; and in reference to the frequent rains, at a point further north than ever reached before, Captain Parry says: —

It is a remarkable fact that we had already [first week of his journey] experienced more rain in the course of this summer than during the whole of seven previous summers taken together, though passed in latitudes from seven to fifteen degrees lower than this.

So he was as much disappointed by the "nubilous deposits" as Dr. Hayes was in Smith's Sound.

Mr. Schott also, like Dr. Hayes, proposed to account for the warm winds experienced by Dr. Kane in Rensellaer Harbor, in January, 1855, by "supposing them to have originated over a *water area*, partially open (this water would have a surface temperature of 29° F.)" By the phrase, "water area partially open," is probably meant open water. It would seem, however, that Dr. Kane had little reason to believe in the open water hypothesis for the production of warm winds of a temperature of 32° as already recorded, whatever his predilections may have been. After passing the month of December, with the mercury from 45° to 57° below zero, he refers to the presence of open water thirty-five miles distant, as follows: —

January 12, 1855. — In reviewing our temperatures, the monthly and annual means startle me. Whatever views we may have theoretically as to the distribution of heat, it was to have been expected that so large a water area but thirty-five miles to the south-west by west of our position would tell upon our records; and this supposition was strengthened by the increased fall of snow, which was clearly due to the neighborhood of this water. [?]

The open water was south of Cape Alexander, and probably had nothing to do with the snow.

Upon the evidence presented in the foregoing pages, we think it is safe to conclude that the reported warm winds — blowing generally from the north and apparently over extensive icy re-

gions, of a very much higher temperature than the open water—cannot be attributed to that source. In the region of the Gulf Stream, the temperature of the water must be at 50° to raise the temperature of the air to 32°; but this relation of cause and effect in the same degree could hardly be expected in the Arctic Regions. To us it seems impossible: we cannot conceive, over a considerable space, of any approximation to it, and have always regarded the idea of a warm wind from a surface of open water, without any actual knowledge of its temperature or the temperature necessary under the circumstances to produce it, as an eminent absurdity, lacking peradventure the elements of possibility. If the need of open water is peremptory, as some theorists appear to regard it, why not take the open sea, believed to exist in the central portions of the Arctic Basin, at once, and refer to that phenomena that cannot be explained or accounted for by open spaces, channels, ports, or walrus-holes in the ice, about which it is well known there is no permanency of continuance? But even here an open sea of 36° would fail to produce an atmosphere of the required temperature to the height of a ship's deck above the surface.

So that, as Dr. Kane suggested, the open water, not accounting for the warm wind or any wind, remains to be accounted for. It is hardly too much to say that open water in the Arctic Regions has been seen everywhere and by every explorer by land or sea. Baron Wrangell, in 1823, thought he saw an "immeasurable ocean;" but Dr. Kane suggested that he forgot for the moment how narrow are limits of human vision on a sphere. This was in latitude 70° 51′. Sir John Franklin, on Garry Island, at the mouth of Mackenzie River, latitude 69° 14′, says "the sea appeared in all its majesty, entirely free from ice." Captain Kellett, in 1849, latitude 71° 5′, sailed through streams and floes for two days, and said the heavily packed ice "seemed to be broken by a water line on the northern horizon."

From the time of Barentz, in 1596, open water has been reported by navigators where it was not generally looked for, and has often been assumed to be either the open sea itself or leading into it. "The Dutch fishermen above and around Spitzbergen pushed their adventurous cruises through the ice into open spaces varying in size and form with the season and the winds; and Dr. Scoresby alludes to such vacancies in the floes as pointing in argument to a freedom of movement from the north, inducing open water

in the neighborhood of the pole." "So, still more recently," says Dr. Kane, "Captain Penny proclaimed a sea in Wellington Sound, on the very spot where Sir Edward Belcher has since left his frozen ships; and my predecessor, Captain Inglefield, from the mast-head of his little vessel announced an *open Polar Basin* but fifteen miles off from the ice which arrested our progress the next year."

Open water of itself, as we have said elsewhere, proves nothing. On the very page that Dr. Kane reported the discovery by Morton of an open sea, it occurred to him that that might prove as illusory as the rest have done; and he says, "How far it may extend, whether it exists simply as a feature of the immediate region, or as part of a great unexplored area communicating with the Polar Basin, may be questions for men skilled in scientific deductions." In a note, he adds, "Whether it does or does not communicate with the Polar Basin, we are without facts to determine. I would say, however, as a cautionary check to some theories in connection with such an open basin, that the influence of the rapid tides and currents in destroying ice by abrasion can hardly be realized by those who have not witnessed their action. It is not uncommon to see such tidal sluices remain open in the midst of winter. Such, indeed, are the Polynia of the Russians, the stromhols of the Greenland Danes, and the familiar open holes of the whalers."

Whatever may be the cause of open water, whether local or otherwise, it certainly is not the Gulf Stream, but rather the winds, tides, and currents, as suggested by Dr. Kane; and their existence is entirely compatible with the nature and character, as far as known to us, of the Arctic Ocean. Sir Edward Parry, in 1827, who travelled over the ice from Spitzbergen to latitude 82° 45′, did not find open water, excepting channels and holes; but he did find ponds of fresh water on the ice which had been much larger than when he discovered them, and these were the result of the rain that he had encountered on his trip. He was disappointed in not seeing "solid fields of unbroken ice which every account had led us to expect in a much lower latitude," but found it rotten and unsafe as he proceeded, and the whole excursion shows that if he could have gone farther he would have found the end of the ice and the open sea.

We might extend these remarks and illustrations indefinitely, and bring together innumerable facts and statements, — such as

relate to the irregularities of the winds towards the pole; the frequency of calms, greater in number than all the winds combined; continued fogs and heavy mists, not the mere result of local causes; the location of the poles of cold; the formation of glaciers, by means of the rains; the absence or comparative sparseness of snow on the Spitzbergen and Greenland Mountains; the falls of rain, "which produced even greater effect than the sun in softening the ice;"— all of which go to illustrate the nature and character of the climate and meteorology of the Arctic Regions, and seem to demonstrate the applicability of the theory here proposed for the solution of the phenomena recorded.

"Peterson tells me," says Captain McClintock, "the same warm south-east (north north-east true) wind suddenly sweeps over Uppernavik in mid-winter, bringing with it abundance of rain."

This warm wind, constantly blowing, and rain, in some form of manifestation, are the experience of the Arctic Regions.

It is this warm wind that produces snow, and changes the fall to rain in summer and winter.

It is this warm wind and rain that melts the snow on the mountains, and softens the ice more than the heat of the sun.

It is this warm wind and rain that cover a ship's rigging and hull with a heavy coating of ice, as described.

It is this warm wind that forms clouds and fogs so constantly, and brings with it electricity,— perhaps for the aurora borealis.

It is this that forms ponds of fresh water on the ice in the north.

This it is, as Captain McClintock believed,— and not mere spaces of open water among the ice-fields, enveloped with a temperature far below zero,— that "mitigates the severity of the climate."

This it is — the current of air from the equatorial regions in the system of circulation already described, charged with heat and moisture, of different degrees of temperature — that produces all the meteorological phenomena of the Arctic Regions, including mirage, mock sun, &c., as well as storms, fogs, and winds.

This it is, too,— the falling of moisture and emission of latent heat in the highest northern regions around the pole,— that,

whatever may be the auxiliary effect of other influences, if any exist, keeps an open sea, wherever it would otherwise be closed.

This it is, too, that locates the poles of cold so far south of the theoretic pole of the earth.

This, in short, is the Atmospheric Theory, and this it is that establishes the fact of an ameliorated climate in the Arctic Regions.

B. NATURAL HISTORY.

I. GEOLOGY AND GEOGRAPHY.

1. Explanation of a New Geological Map of New Hampshire. By C. H. Hitchcock, of Hanover, N. H.

(Abstract.)

This map is constructed upon the scale of two and a half miles to the inch. The topographical part has been laboriously compiled by H. F. Walling, from all existing sources, which are chiefly these: — 1. Coast Survey maps and triangulation. 2. Triangulation by E. T. Quimby, under the direction of the Geological Survey. 3. Map of the Northern Boundary, by Colonel J. D. Graham, made by the United States after the ratification of the Treaty of 1842 with Great Britain. Colonel Graham's astronomical observations gave the same figures for latitudes and longitudes as those subsequently deduced by the Coast Survey. 4. Ten County maps, constructed after odometer surveys. 5. Maps of Connecticut River, Winnipiseogee Lake, and others too numerous to mention.

It is expected that this map, showing as it does minutely the natural topographical features of the country, with all the villages, roads, railroads, &c., will form the basis of the Geological Map to be inserted in the Final Report upon the Geology of the State.

A previous paper has given in detail the formations among the White Mountains. The scale of the map will enable us to show them all, with many other details in the south part of the State.

In general they may be grouped as follows: —

I. Eozoic.

1. *Laurentian*, including (*a*) porphyritic gneiss; (*b*) White Mountain series, or andalusite gneiss; (*c*) Bethlehem, or talcose gneiss;

(*d*) gneiss of Lake Winnipiseogee Basin; (*e*) gneiss on both flanks of the porphyritic variety in the south part of the State, subdivided by bands of quartzite, — this carries the Concord and Fitzwilliam granites, and is probably the beryl-bearing series also; (*f*) range of gneiss between Whitefield and Milan, considerably hornblendic.

2. *Norian*, including (*a*) common granite; (*b*) trachytic granite; (*c*) four bands of felsite, both labradorite and orthoclase.

3. *Exeter syenites*, including those cutting the Norian at Waterville, Mount Monadnock, opposite Colebrook, Red Hill, &c.

4. *Huronian.* The talcose schist series along Connecticut River, and in the north part of Coös County.

5. *Older Cambrian?* Includes Coös and Merrimack groups, and probably the "Calciferous Mica Schist" of Vermont Survey.

II. Palæozoic.

Helderberg limestone.
Clay slates.

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2. Recent Geological Discoveries among the White Mountains, New Hampshire. By C. H. Hitchcock, of Hanover, N. H.

At the Troy Meeting (1870) I had the honor to present to the Association a brief sketch of the *Geology and Topography of the Mount Washington Range.* The communication was of a verbal character, and no abstract of it prepared for publication. I exhibited a model of this main range, upon the scale of one hundred and forty rods to the inch horizontally, and five hundred feet to the inch vertically, upon which different colors indicated the distribution of the principal varieties of rock. The area there represented was comprised between the Saco, Ellis, Peabody, and Moose Rivers; and the formations consisted of the andalusite or White Mountain gneiss, granite of three kinds, traps, and the andalusite

slate or Coös group. The opinions that had been entertained by previous explorers, in regard to the age and structure of the White Mountains, received a brief notice; and a new theory of the structure of the Washington range was presented. The main range was considered to be an inverted anticlinal, much disturbed in a later period by a powerful force, exerted nearly at right angles to the direction of the original compressing agency.

The name of *White Mountain Series* or *Rocks* is proposed in my Report to the Secretary of State, in 1869, as a general term for all the older gneissic and granitic rocks occupying the mountain area, and the principal part of the State, east of the newer series of schists and slates along Connecticut River, described as the *Coös group*. The first of these terms is a general one, which may be restricted in application as our knowledge of the formations becomes more definite. Both in 1869 and 1870 I insisted that the White Mountain series of andalusite gneiss and the andalusite slates represented two very different geological periods, the latter being the most recent, and thought to be of the same age with the staurolite schists along Connecticut River.

Since 1870, my researches have been extended over the White Mountain area west and south of the Washington range, among quite a different series of rocks. The region is entirely a forest and mountainous country, whose exploration is conducted with extreme difficulty. Our conclusions differ greatly from those of any earlier writer, and they spring directly from the observations in the field. Geologists may differ from me in referring these rocks to the periods I shall name hereafter, but they will be satisfied that their sequence is properly made out.

As a matter of convenience, I will specify the several discoveries in the order in which they presented themselves to me. Mr. J. H. Huntington, my assistant, has toiled diligently among these mountains, and has contributed largely to the development of the structure, as we now understand it.

I. Discovery of the Norian System.

In his address before the Association last year, at Indianapolis, on retiring from the presidential chair, Dr. T. Sterry Hunt remarked that the Labradorian or Norian system, "although occupying a considerable area in the Adirondack region, is not certainly known in the Appalachian range." Not more than a day later it

was my privilege to stand upon a Norian area of several square miles in extent, in the town of Waterville; and since that time the system has been discovered in seven or eight other localities: so that the remark of Dr. Hunt, true when uttered, is no longer correct. A brief sketch of this locality in Waterville will be of interest. Near the east line of the town of Waterville is a high mountain, called "Tripyramid," for the reason that from an oval base three conical peaks rise to nearly the same height, the highest being 4086 feet (Guyot) above mean tide water. The course of these summits is ten or fifteen degrees west of north. From Chocorua and Kiarsarge Mountains the northern cone seems farther away from the middle than the southern one, and there are two subordinate elevations each side of the centre. Bond gives four peaks on his map corresponding to Tripyramid, the two southern 4400 feet each, the others 4300 and 4000 feet above the sea. The whole mountain mass is isolated, and is therefore quite prominent. The southern peak is about three miles westerly from Passaconnaway, in Albany, and four from Whiteface, in Sandwich, both of nearly the same altitude; while Osceola, on the boundary line between Waterville and Allen's grant, is 4397 feet above the ocean, and not less than six miles away. The Grafton County map improperly calls Tripyramid Passaconnaway; and, misled by this authority, many persons have fallen into error in their descriptions of localities. Eastman gives no name to this peak on his map.

The notable storm ending October 4, 1869, gave rise to a remarkable freshet upon the south-western slope of the most southern of these pyramids. The mountain side seems to have been covered by spruces growing above loose blocks carpeted abundantly with moss, very much as is common all over the White Hills wherever the climate permits temperate vegetation to flourish. No valley furrowed the slope; and it seems difficult to understand why the waters should have accumulated so enormously at this point, and nowhere else in the neighborhood, if we may judge by the effects produced,—especially since the bare mountain side, exposed at this time, has rendered the area conspicuous as a landmark fifty miles away. It were easy to imagine that some atmospheric disturbances had collected the waters from a circle having a diameter of a mile, and discharged them in a narrow stream upon the forest beneath. Clouds are sometimes said to "burst," when their contents are poured very quickly into some limited area, most usually when a tornado or rapidly formed

nimbus flits by. Yet something of a similar character will best explain the phenomena displayed in Waterville during this never-to-be-forgotten storm.

Almost immediately after the storm, this locality was visited by Professor G. H. Perkins, Ph.D., of the University of Vermont, Rev. M. T. Runnels, of Sanbornton, and Charles Cutter, of Campton. Professor Perkins wrote a description of the changes wrought in the country, and published it in the "American Journal of Science" (II. vol. xlix. p. 158). As he made careful estimates of distances in the upper part of the mountain, I will use his figures in the paragraph that follows.

The sliding commenced about forty rods from the summit, a little one side of the highest point. The beginning of the bare earth is only a rod in width. The breadth increases gradually for fifty or sixty rods. For the following seventy rods down hill it widens rapidly, attaining at one hundred and thirty rods' distance a width of twenty-five or thirty rods. Thirty-six rods lower the breadth is seventeen rods. The course is nearly straight to this point — one hundred and sixty-six rods — when it begins to curve towards the north-west instead of continuing south-westerly, and eighty rods below is what Professor Perkins regarded as the termination of the slide. The waters excavated a gorge through the boulder clay or "hardpan" of the country, after passing the Elbow, often twenty-five feet deep, the material being almost as firm as solid rock. The whole course thus far mentioned is two hundred and forty-six rods, of a general fusiform outline, with the lower end curved to one side. The inclination of the débris is often as much as forty-five degrees, perhaps higher for a dozen yards, and generally somewhat less. The underlying ledges appear in two or three places, but do not exhibit any marks or scratches made by the sliding mass.

The curve at the bottom of the hill is nearly a right angle, and was determined by the configuration of the land, for directly in the way of the slip there is a low ridge covered by a forest. Were the phenomenon a true slide, the materials must have been arrested by this obstacle. But no more earth lies before this obstruction than along any part of the two or three miles' distance of the steepest descent below. The forest must therefore have been torn up by a prodigious freshet,— trees, earth, and rock fragments mingling with the water, as if all a liquid mass, winding through the curved valley of a stream, and excavating a deeper channel below the

turn in its direction. In a clearing of fifty acres at the base of the mountain, called "Beckytown," great piles of rubbish, rocks, and trees accumulated, while only earth was transported farther.

For nearly two miles below the Elbow mentioned above, the current descended rapidly, occasionally depositing gravel in protected nooks, which, with other sloping surfaces, may be called terraces. Quite high up is an interesting excavation in the form of a notch, where one side is long, sloping gradually, and the other steep and short. Half way down the stream — which may appropriately be termed Norway Brook, on account of the name of the formations traversed by it — the water falls precipitantly over a ledge of the dark Norite rock. Elsewhere the valley is like that of any mountain torrent.

This locality is easily accessible. During the summer a stage runs from Plymouth to Greely's Hotel, in Waterville, a distance of twenty miles. From this summer resort the first of the Norite ledges is less than two miles, over a well-defined footpath, and passing near a picturesque cataract. Mr. Greely can direct visitors to these rocks.

The locality was first visited in a scientific way by Dr. Perkins, in 1869, who did not recognize the Labrador feldspar. In May, 1870, Mr. J. H. Huntington went up the stream, bringing back specimens of the dark rock, which he suspected might be labradorite. He carried a fragment of it to Dr. T. Sterry Hunt, of Montreal, for examination. Dr. Hunt's analysis showed the predominant mineral to be labradorite, in a letter dated March 21, 1871, and addressed to Mr. Huntington.*

My first visits to this locality were made August 18 and 19, 1871; also, September 20, in company with Professor J. D. Dana. A short article, descriptive chiefly of this locality, appeared in the "American Journal of Science," for January, 1872, written by myself, followed by analyses of the labradorite and chrysolite by Mr. E. S. Dana. As the principal rock proved to be an aggregate of labradorite and chrysolite, an assemblage of minerals not heretofore described, Mr. Dana proposed to designate it by the name of *Ossipyte*, after the tribe of Indians indigenous to this part of the State.

In ascending from "Beckytown," the first rock met with is

* See Report of the Geological Survey of the State of New Hampshire, for 1871.

"trachytic granite." This I called "gneiss with nodular orthoclase," in my first sketch, with seams or strata dipping (by compass) 80° south, 70° west. In no other locality do the scales of mica arrange themselves in planes nearly vertical to the jointed surfaces. A careful examination of this granitic rock in numerous localities leads to the conclusion that it is a true erupted granite, and not a gneiss; though it is possible the present case may be an exception. If so, it would be connected directly with the porphyritic gneiss of Cascade Brook.

The first ledge of *ossipyte* appears a few rods higher up. Its junction with the granite is concealed by drift. Similar ledges occur for a mile, some exposures being sixty or seventy feet long. The rock seems to be stratified, the planes dipping about twenty degrees northerly.

This dark rock is abruptly succeeded by a gray syenite-appearing rock, being sometimes labradorite and mica, with hornblende; then orthoclase, labradorite, and mica, with scarcely any hornblende. The line of junction is irregular, averaging north 20° east, and cutting the strata. Cavities in the strata have been filled by injected masses of this syenite. For these reasons, we believe this rock to have been eruptive. Perhaps an eighth of a mile higher up, we find an interesting assemblage of coarse crystals of whitish labradorite, hornblende, titanic iron, mica, and epidote. This is at the "Notch."

These ledges disintegrate very rapidly. Large nodules of the syenitic rock, less liable to decomposition, are scattered through the mass; and there are geodic cavities containing orthoclase, albite, quartz, and rarely stilbite. The "Notch" is produced by the erosion of a ferruginous band, resembling a stratum, and dipping both east 15° south, and east 35° north. Above the Notch, as far as the "Elbow," there is a recurrence of the finer-grained syenite, containing geodes and feldspathic veins. At the Elbow there is a somewhat different mineral combination, extending to the top of the Pyramid. Quartz is rare, but there are two kinds of feldspar. Mica is abundant, and some specimens show hornblende. The same minerals occur in the geodic masses, as below; also actinolite, amethyst, and others yet undetermined.

Two analyses of one of the feldspars by C. A. Seely gave the following results: silica, 59.2; alumina, 28.8; iron oxide, trace; lime, 7.4; soda, 8.54; potash, 0.6. A partial determination of another specimen gave: silica, 57.6; alumina and iron oxide,

not separated, 24.6; lime, 3.2. These analyses are suggestive of *andesite.*

Upon the north-east side of Tripyramid, Mr. Huntington found a similar order of ledges in ascending that tributary of Swift River, called Sabba Day Brook. Near the mouth of this stream there is a cataract falling over the common granite of the country. The same appears a mile higher up. The same rock is found on Down's Brook, another tributary of Swift River, passing very nearly along the line between Waterville and Albany. The trachytic granite was not observed here, possibly because we had not learned the importance of distinguishing it at the time of the visit. But, higher up Sabba Day Brook, Mr. Huntington found compact labradorite in places apparently devoid of chrysolite, and fragments whose cleavable crystals showed the play of colors usually seen in this species. Higher up the mountain, the north Tripyramid, the syenitic rocks of the slide reappear. Farther south the labradorite passes up into a breccia apparently overlying gneiss.

The rocks adjacent to this Norian area are the trachytic granite at Beckytown, on Norway Brook, and probably on the north, since specimens of it have been brought from Flume Brook, two miles distant; common granite to the north-east; gneiss on the east; and porphyritic gneiss on the south. The latter crops out upon Cascade Brook, about a mile south of the Norian. The ridge between has not been examined. This gneiss dips 75° north 20° east, and most likely lies underneath the labradorite rocks unconformably. These porphyritic ledges seem to be the northern end of continuous exposures all the way from Fitzwilliam, ninety miles distant, if not from Massachusetts. The breadth is sometimes fifteen miles. Hence the labradorite rocks seem to rest conformably upon the trachytic granite, to have been cut across by the syenite, and to overlie uncomformably the other formations adjacent. With this point settled, it is easy to determine the relative ages of all the formations concerned.

The importance of this discovery may be best appreciated by remembering that the presence of the lime feldspars affords a strong presumption that these rocks are Eozoic, and not metamorphic Paleozoic formations. It seems to be generally admitted by geologists that these feldspars are confined to the older rocks, except as found in eruptive trappean and volcanic masses. The Labrador system was first formally separated from the Lau-

rentian by Sir W. E. Logan, in his Report of 1865, though the proposal had been shadowed forth in earlier reports. It is called the *Upper Laurentian* or *Labrador*. Dr. Hunt subsequently proposed the name of *Norian*, from Norway, instead of Labrador. The Canadian geologists supposed this system to underlie the Huronian, though the two groups had never been found in immediate contact. They are positive that it is more recent than the Laurentian, as it overlies the earlier gneisses unconformably.

With this history before us, it is not strange that we began to take a deep interest in tracing out the relations of these Norian rocks, as well as to accept the conclusions presented above, in regard to the value of lime feldspars in determining geological age. The felsites have since been discovered in several localities, but almost always possessing a slight dip. Regarding all the compact feldspars as belonging to one system, though differing chemically, the series may be divided into four parts.

First, the *ossipyte*, or other coarse aggregations of labradorite with hornblende or other minerals; second, a dark, compact lime felsite, verging into one of similar aspect, but hardly a labradorite. That from the Lafayette range represents the first of these varieties. The following is its composition: silica, 52.01; alumina, 26.60; iron peroxide, 4.20; lime, 13.30; soda, 3.50; potash, 0.65. Total, 100.26.

The second of these varieties may be represented by a specimen from Mount Lyon (Cape Horn) in Northumberland. The following is its composition: silica, 62.2; alumina, 28.0; iron oxide, trace; lime, 4.6; soda, 3.34; potash, 6.0. This is like an ordinary potash felsite. These two kinds cannot be distinguished from each other optically.

Third, crystalline felsites of light color, often reddish and most probably orthoclase. There are mountain masses of this kind, as exemplified upon Mount Carrigain and Twin Mountain.

Fourth, compact red felsite, resembling orthoclase. One of them from Albany gives the following percentages: silica, 64.90; alumina, 8.80; iron oxide, 12.60; magnesia, 2.37; lime, 3.50; soda, 4.24; potash, 6.25. Another from the north of Waterville gave for alkali determinations: soda, 3.959; potash, 6.525. There is no reason to suppose that any of the red felsites found by us differ essentially from orthoclase in composition.

The localities of these felsites may be briefly mentioned: 1. Waterville, as described above; 2. Albany, upon Mount Chocorua,

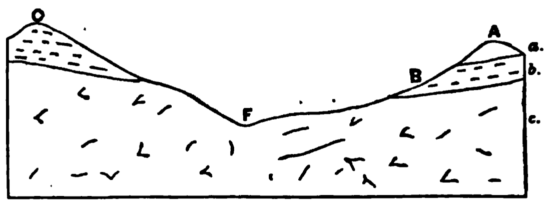
and 3. Little Deer Brook. The last is connected with an interesting conglomerate, partly composed of two varieties of felsite and partly of andalusite rocks. 4. Loon Pond, in Woodstock. 5. Mount Carrigain. 6. Twin Mountain range. The felsites occur chiefly south of the summit of the north peak, and north of the east branch of the Pemigewasset. 7. Lafayette range. 8. Mount Tom, near the Crawford House. 9. A few miles from the summit of Mount Washington, in the valley of Dry River. An examination and analysis of this rock shows it to be almost exactly like that from Waterville, analyzed by Dr. Hunt. 10. Sable Mountain, in Jackson. 11. The largest of all, extending from Mount Starr King, in Jefferson, to Northumberland. Two peaks in Northumberland are actually separated from the main area by an intervening band of argillaceous quartzite. This area of perhaps sixty square miles is full of sharp, precipitous peaks; and, though often only a mile from a railroad, the primitive forest has never been removed from them, so poor is the soil. Wherever exposed, the ledges decompose rapidly, and hence one might by a hasty examination overlook the true mineralogical character of these felsite summits. Perhaps, on account of ready decomposition, it is very rare to see any boulders of this felsite in any of the settled districts, otherwise attention would have been directed to them long ago.

II. Relations of the Granites.

Mount Lafayette is the culminating point of a narrow ridge, about five miles long, capped horizontally by lime felsite, except at one low and narrow place, where it has been worn away. The thickness of the felsite is not more than two hundred or three hundred feet. Passing down the west side of this range, say next the Flume, one passes over two kinds of granite, arranged in two immense sheets, like conformable formations underneath the felsite. This arrangement may be best appreciated by inspecting the annexed section from Mount Liberty to Mount Flume, passing through the celebrated gorge in Lincoln called the "Flume," *F*. Mount Liberty is at *C*, and Mount Flume at *A*, 2250 feet above *F*, which is 1849 feet above mean tide water. In ascending, one passes over say six hundred feet thickness of a common granite, and above that over about one thousand feet thickness of the trachytic granite, before coming to the felsite.

The constituents of the common granite are the ordinary orthoclase, mica, and quartz. The minerals are rather coarse, usually one-fourth of an inch in length, and never more than an inch. The orthoclase is often flesh-colored to red, and is the most abundant of the constituents. The quartz is smoky, translucent, sometimes roughly crystallized, though commonly amorphous. The mica is black, and the least abundant of the three, but existing in considerable quantity. Nearly horizontal joints traverse the mass, besides others that are perpendicular.

The trachytic granite abruptly replaces the common variety in ascending. It has a strongly trachytic or semi-porphyritic aspect. It is chiefly feldspar, proved by analysis to be orthoclase, in rounded crystals imbedded in a granitic paste; the former being the chief part of the mass. Sometimes pieces of quartz are scattered among the feldspar crystals. The rock is often characterized by a film of manganese, perhaps coloring an entire mountain



a. Felsite. *b*. Trachytic Granite. *c*. Common Granite.

mass. In different parts of the mountains this trachytic rock varies slightly, — perhaps becoming more compact, as in Albany, or more micaceous, as near Mount Osceola.

Throughout the White Mountains, at least south of the Lower Ammonoosuc River, it is easy to distinguish these two varieties of granite, and they invariably hold the same relative position to each other everywhere. It is as easy to know the mineral character of these mountains from a knowledge of the rock at their bases, as that of the high mounds about Dubuque where we have the succession of Trenton, Galena, and Maquoketa, or Lorraine. For if the basal layer is common granite, we are sure to find first the trachytic variety, then coarse labradorite or ossipyte, and then finer lime felsites, followed by others, according to the altitude. To prove this statement, I need only refer to the Lafayette and Twin Mountain ranges where the whole series is exposed, or to Mount Osceola where only the two granites appear.

If these granites behave like a stratified formation, of course the question is at once raised whether they should not be regarded as true strata. The answer cannot be given from position merely, since it is not uncommon to find sheets of trap or lava holding a perfectly analogous position. We have preferred to think of the White Mountain country at the end of the Laurentian period as an immense basin, upon which there was an overflow of common granite. Being liquid, it spread itself out like water, assuming a horizontal surface. After a while there was an eruption of trachytic granite, which spread itself in the same way. Subsequently the felsites were formed above them, conformably. It would be natural to regard these granites and the felsites as belonging to one period, the Norian. The limits of this system have not been fixed; and it seems as if in New Hampshire it should commence with the common granite, and end with the red orthoclase felsite.

As these formations still preserve the nearly horizontal arrangement, it would appear that the region has not been much disturbed since the deposition of the felsite, certainly not enough to incline the strata at any considerable angle. Other considerations indicate that the principal upheaving agency acted in an earlier period.

III. The Laurentian.

If the felsite series is of the age of the Upper Laurentian or Labrador of Logan, then by the law of superposition the strata underneath the common granite are Lower Laurentian. Observation showed us, at this phase in the development of the White Mountain structure, two gneisses and a breccia underneath the granite sheet.

The most important is the "*Porphyritic gneiss*," or granite sometimes. This is a gneiss having large crystals, usually one and a half inches long, of orthoclase, arranged in layers in the mass, with the longer axes parallel to one another. These we conceive to be the strata. The formation is immensely developed in the State. Perhaps three ranges of it occur in the White Mountains. The principal one passes from Campton, up the Pemigewasset valley and the Kinsman-Moosilauk range to the north part of Franconia. Another mass of it, four or five miles long, crops out in Littleton and Bethlehem, apparently connected with the Franconia end of the range beneath the "Bethlehem gneiss." Another range is overlaid in Waterville by the Norian,

but appears again in a small outlier at the base of Mount Carrigain.

The descriptions of the Laurentian rocks in Canada and Europe make mention of large quantities of porphyritic gneiss; hence we feel warranted in referring these lower schists to the Laurentian system. We have yet found nothing older in the State.

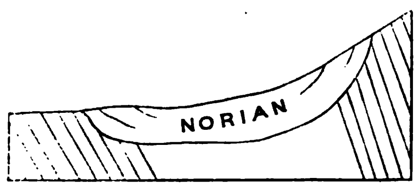
The "Bethlehem gneiss" overlies the porphyritic variety. This rock is characterized by the presence of chlorite, or else the green pinite which constitutes the principal ingredient of the so-called talcose schists of Northern New England. The rock is generally very granitic; *i.e.*, the strata are not easily made out. The formation lies between Littleton and Randolph, and has in general an east and west strike; while the dip is nearly perpendicular.

The breccia referred to this period occupies two small areas in Franconia, joining the common granite at the "Basin." It holds abundantly fragments of porphyritic gneiss and ordinary gneisses, but no pieces either of the common or trachytic granites. The two areas are separated by the common granite, which seems therefore to overlie it.

IV. Relations of the White Mountain Gneiss.

While these explorations were in progress in the field, Dr. T. Sterry Hunt, of Boston, devoted his attention to the study of the relations in age of the three great gneissic areas of New York and New England, and embodied his conclusions in the Presidential Address delivered at Indianapolis, in 1871. I need only refer to the character and place of his "White Mountain series." He used the term in a different sense from that alluded to at the outset. He included all the schists, both gneisses and non-feldspathic layers, containing either the minerals andalusite, staurolite, or cyanite, or that class of silicates of alumina devoid of alkalies. And he referred the age of the series to the *Cambrian*, not far from the period of the Potsdam sandstone. Our observations enable us to subdivide this series, in accordance with our original definition (see *ante*), and confidently to refer the lower division to the Laurentian system; while the non-feldspathic portion lies above the Norian, and may hold the position ascribed by Dr. Hunt to the whole White Mountain series, in his very able and learned address.

The truth flashed upon us while studying the strata along Dry (or Mount Washington) River, four or five miles south of the Tip Top House. Passing from any part of the main ridge (from Mount Washington to Jackson) into this valley, we see only the common gneiss of the mountains, often carrying bits of andalusite. The dip is high to the north-west, and there are minute contortions. There are several varieties: common granitic beds, mostly quartzite, and a gneiss reminding one of the porphyritic variety. These same members were observed upon two tributaries of Dry River, one rising from the notch between Mount Pleasant and Mount Franklin, the other from the notch between Mount Clinton and Mount Jackson. Between the mouths of these tributaries an ossipyte, with other labradorite rocks, crops out. An analysis of the labradorite, carefully removed from the ossipyte, shows it to be composed of silica, 51.50; alumina, 25.90; peroxide of iron, 5.00; lime, 4.29; soda, 2.95; potash, 0.50. Total, 100.14. The



White Mountain Gneiss.

labradorite rocks assume the form of a shallow synclinal, lying upon the upturned edges of the White Mountain series, as shown in the accompanying figure. The dip is greatest on the lower end of the outlier, and the quartzite variety underlies it there. The junction between the two formations was carefully studied at the upper end, where it is of the most importance to see their relative positions. The lime feldspars clearly rest upon the gneiss, and the line of junction was followed up a stream a considerable distance.

This outlier is not more than one and one-half miles in length along the river. We have not yet explored the forests on the two banks, but do not think it is as broad as long. The section is also interesting because it shows that the granites were produced in the interval between the deposition of the gneiss and the formation of the lime feldspars. It also indicates that the principal epoch of elevation among the White Mountains preceded the

Norian period, or at the close of the Laurentian. This statement presupposes what must be inferred from this section in regard to the age of the White Mountain gneisses, that they may be Laurentian. It is easy, therefore, to divide the Laurentian of the White Mountains into three parts: first, the porphyritic; second, the andalusite gneiss; and third, the Bethlehem gneiss. There are, doubtless, other well-marked divisions whose characters can be best made out after comparing the rocks of the northern with those in the southern part of the State.

By studying the map — not here reproduced — the White Mountain series is seen to be cut off entirely by the granites west of Jackson. But there are several small outliers of the gneiss in the midst of the granite, usually in the lowest parts of valleys. A good example may be seen about a mile above the junction of Mount Washington and Saco Rivers. Mountains of granite rise one or two thousand feet upon both sides of the river, but close by the water is a quarter of an acre of the quartzose variety of the gneiss, showing precisely the same dip and strike as where it was last seen higher up, before the interposition of the granite. A view of these phenomena immediately suggested that the schists were not actually cut off as might be supposed, but the granite simply overflowed them like water over the floor of a hydrographic basin, leaving here and there an island. Under these circumstances, deep excavations would also uncover small patches of the rocky floor, as in this instance.

This suggestion may throw great light upon the distribution of granite. All of us, who have studied the granites of New England, have been puzzled by the immense areas of this rock appearing at the surface. To relieve the difficulty occasioned by the immense amount of granitic material, provided it descended deep into the crust, it has been supposed that it would be found extensively inter-stratified with schist, or else that the observations required correction. If we suppose the granite may often exist as a comparatively thin overflow, like volcanic areas, the difficulty is removed. It would neither be found in such enormous quantity as supposed, and the observations as to its area may be received as correct.

V. The Breccias of Mounts Kiarsarge and Mote.

Recent explorations show that Mounts Kiarsarge and Mote are much like each other in mineral composition. At their foundation is the common granite. Next comes a thin sheet of trachytic granite, presumably less than two hundred feet. The labradorite does not succeed next, but a clay slate upon Kiarsarge. There are two small outliers of this rock, upon opposite sides of the mountain, neither of them a mile long. Higher up the rocks, on both elevations, are breccias, at first almost entirely composed of fragments of slate, and afterwards the number of slate fragments diminishes. The paste sometimes resemble trachytic granite. The Mote Mountain mass contains fragments of clay slate, andalusite slate, red felsite, and labradorite. Hence the epoch of eruption must have been subsequent to the formation of the clay slate (supposed Cambrian).

In Albany there is an irregular area of a greenish granite, overlying the trachytic variety, and beneath the breccia. A similar rock occurs on the Hancock Branch of the Pemigewasset, and probably elsewhere, as our attention has only just been called to it. The Albany area is represented upon the map. It may be that this third species of granite was erupted at the time of the breaking up of the slate. Further explorations are needed to make its history thoroughly understood. The largest part of the area occupied by this variety lies between Mounts Chocorua and Passaconnaway.

Order of the Formations.

We may then conclude the following to be the proper order of the formations in the White Mountain area:—

1. The porphyritic gneiss of Bethlehem and Littleton, the range from Franconia to the south part of the State, an outlier along Sawyer's River south of Mount Carrigain, and the range passing south-westerly from Waterville. These may be grouped in two parallel ranges, the country between and to the north being occupied by newer groups. There is also limited evidence of the existence of a third range to the west of both those mentioned.

2. The White Mountain series of gneisses and mica schists carrying andalusite probably succeed. A difference in the strike of those two groups in Thornton suggests the possibility of an interval of time between their respective depositions.

3. The Bethlehem gneiss rests unconformably upon the first-mentioned rock. Its relations to the second series are yet unknown. All these groups are probably of Laurentian age. They seem to have been elevated before the commencement of the following period. Perhaps the era of disturbance is represented by —

4. A singular breccia, not yet seen away from Franconia. It occupies two areas, one on each side of the Pemigewasset valley. The fragments are mostly of porphyritic gneiss, with schists supposed to be of the second series. The areas are separated by the common granite, which was probably ejected in the following period, since none of its fragments appear in the adjoining breccia.

5. The Norian series. These, as already mentioned, consist of (*a*) common granite; (*b*) trachytic granite; (*c*) ossipyte; (*d*) compact labradorite felsite; (*e*) dark compact orthoclase felsite; (*f*) red compact and crystalline orthoclase felsites.

6. Period of the eruption of the syenites of Tripyramid, Red Hill, &c.

7. There seems to be a blank in the direct sequence of events after the eruption of the syenites. A clay slate succeeds the Norian directly in the vicinity of the Crawford House; and were this the only locality where the lower and upper layers appear in contact, there would exist no evidence of the immense thicknesses of schists which have probably been intercalated at this horizon. In Stark and Northumberland, a dark silicious rock, somewhat argillaceous, more or less suggestive of the slates of Mounts Tom, Webster, and Willey, lies adjacent to the felsites, but standing vertically, and usually at a lower level. Supposing the slaty rocks of Willey and Stark of about the same age, and both subsequent to the Norian group, their present position may perhaps be explained thus. The older Laurentian and the felsite deposits may have been very firmly established, so as not to suffer great disturbance. But the forces of upheaval continuing to act, they may have been brought nearer to each other by lateral action, yet not in such a way as to tilt the strata. The consequence would have been the crowding and upheaval of the strata formed in the basins between the earlier hills. These latter being near together, the slates may have been thrown upon their edges without disturbing the horizontality of the former. This view will not indicate how long a time elapsed between the close of the Norian and the

beginning of the Coös (or slate) periods. Our explorations reveal not less than three great groups which it is reasonable to suppose filled this interval of time. They are (1) a range of gneiss between Whitefield and Errol; (2) another gneiss running south from Landaff; and (3) the green schists of the Ammonoosuc and Connecticut valleys, called "Quebec" in my first report, but perhaps better referable to the *Huronian* of Canada. To prove this to be the proper place of these great groups will require further study.

8. The place of the clay slates of Mounts Tom, Willard, Kiarsarge, &c. Closely connected with them are the andalusite slates or schists found along the carriage-road up the east side of Mount Washington. These may be referred to the Cambrian, from lithological resemblances.

9. Other disturbances followed. This was most likely the era of the eruption of the greenish granites of Albany; certainly the time when the breccias of Mounts Kiarsarge and Mote accumulated from the breaking down of the Coös rocks. These slates show marks of powerful disturbance near Conway, and also upon Mount Washington.

10. The latest period of unrest among the mountains, of which any evidence is afforded, is indicated by the presence of highly inclined Helderberg limestones in Littleton, beyond the proper area of the White Mountains. The mountains, however, must have moved westerly in order to elevate these Devonian rocks. The period is probably the one considered by most previous authors as the time when the White Mountains themselves were projected into the air, at the close of the Palæozoic age.

The complete history of the White Mountain area would require some notices of the Glacier or Drift Period. The lateness of the hour will prevent the elucidation of this chapter in the history.

Thus our explorations have brought to light the existence of ten distinct periods, whose records can be traced upon the scarred sides of these highest mountains in New England. No previous essay speaks of more than two. If our limited opportunities have led to such unexpected results, what may we not look for when the geological structure of the entire metamorphic area of New England has been carefully studied! It is strange that this interesting region has been so thoroughly neglected by geologists.

3. THE SURFACE GEOLOGY OF NORTH-WESTERN OHIO. By N. WINCHELL, of St. Anthony, Minnesota.

THE Geological Survey of Ohio, now in progress, has brought under careful and systematic observation one of the most favorable fields for the study of the phenomena of the Post-Tertiary. Its most interesting feature is the series of long and nearly parallel ridges which are traceable across the country, sometimes for a distance of over a hundred miles, commonly known as *lake-ridges*, sweeping far toward the south and west, and entering the States of Indiana and Michigan. It is a circumstance peculiarly favorable for the study as well as for the preservation of these ridges through their long continuity, that the geological conformation of the rocky surface below is uniformly smooth throughout the whole of the district which they traverse. The rocks have, in North-Western Ohio and North-Eastern Indiana, in general, one common character. They are the limestones ranging from the *Niagara* to the *Black Slate*, including both. These are spread over double their usual superficial area of outcrop by the occurrence of an anticlinal axis — of which the *Niagara* forms the arch — which runs south-westward from the west end of Lake Erie, nearly uniting with the Cincinnati axis of upheaval. The *Salina*, which by its erosible character has played an important part in determining the location of some of the great lakes of Central North America, is found wanting in the geological series in Ohio, south and west of Lake Erie. It has a feeble existence round the shores on the south, giving rise to some of the deepest indentations of coast; but it is very soon replaced by that member of the *Helderberg*, known as the *Waterlime* in the Reports of the Ohio Geological Survey, thus forming an unbroken chain of calcareous rocks of very uniform hardness, including the *Niagara*, the *Waterlime*, the *Corniferous* (Lower and Upper), and the *Hamilton*. To this list must be added the *Black Slate*, the endurance of which under the forces of the glacial epoch entitles it to be ranked with the most persistent of the palæozoic formations.

This series of rocks occupies the surface of most of the Fourth Geological District of Ohio; *i.e.*, from the Sandstone area in the central portion of the State, westward to and across the boundary

line into the State of Indiana, and a strip along the west end of Lake Erie extending into Michigan.

The whole of this tract is a vast plain of uniform and monotonous character. It was originally densely wooded, with the exception of a few flat tracts now known as prairies, which were too wet throughout the germinating season of the year to permit the growth of trees. It is now being cleared, drained, and occupied by farmers. The "Cliff Limestone" here, unlike its appearance in other parts of the country, is unworthy of its ancient name. It never rises in *cliffs*. There are no sudden changes of level. The drainage of the country is almost entirely independent of the tortuosities of the geological boundaries. The whole district is a vast *tabula rasa*, on which the history of the Post Tertiary is written without those perplexing and disguising variations which have very often misled the student who would read it in more rocky and broken places. This is particularly true over the areas of the Niagara and Water limestones. While the rock itself does not rise in abrupt escarpments, nor sink in deep depressions, there is, besides a general slope of the surface toward the valley of Lake Erie, a series of ridges and undulations, pertaining to the drift, which have had a marked influence in giving direction to the streams.

By the term *drift* is meant every thing which lies on the rocky surface, including boulders, gravel, sand and clay, whether stratified or unstratified, of whatever thickness, and whether separate or mixed.

By the term *unmodified drift* is meant that drift which lies as the glacier deposited it, whether stratified or unstratified. If stratified and assorted, it was done by streams of water issuing immediately from the ice of the glacier, or by water choked and confined in pools or lakes round the foot of the glacier.

Modified drift is that which has subsequently been submerged, and its arrangement and character essentially changed. It may be stratified or unstratified. The drift of the *Bluff Formation* of the Mississippi Valley, and all alluvium of smaller streams, as well as the sand which lies about the shores of the great lakes, are examples of modified drift.

By the term *hardpan* is meant that portion of the unmodified drift which embraces gravel, boulders, sand, and clay, heterogeneously mixed, generally plastic, and impervious to water. The boulders of this clay, in North-Western Ohio, almost invariably

show glaciated surfaces. It has sometimes been called "boulder clay."

In this discussion of the Surface Geology of North-Western Ohio, we shall accept the glacier theory of Professor L. Agassiz as the only satisfactory way to explain the various phenomena there disclosed. It is believed that the simple approach, prolonged presence, and slow retreat of a glacier covering the region under consideration, will account for all its drift phenomena; and that there is in North-Western Ohio no evidence either of the Champlain or the Terrace Epochs, as those terms have been defined and applied to States further east.

In this discussion the subject will be divided in the following way: —

I. The Character of the Drift in general.

(*a*) Where consisting entirely of hardpan.
(*b*) Where the surface is laminated.
(*c*) How the drift was deposited.

II. The Moraine Ridges.

(*a*) The *St. John's Ridge.*

α. Its location.
β. Its external form.
γ. Its contents.
δ. Its altitude above Lake Erie.
ε. Its origin.

(*b*) The *Wabash Ridge.*

α. Its location.
β. Its external form.
γ. Its contents.
δ. Its altitude above Lake Erie.
ε. Its origin.

(*c*) The *St. Mary's Ridge.*

α. Its location.
β. Its external form.
γ. Its contents.
δ. Its altitude above Lake Erie.
ε. Its origin.

(*d*) The *Van Wert Ridge.*

- α. Its location.
- β. Its external form.
- γ. Its contents.
- δ. Its altitude above Lake Erie.
- ε. Its origin.

(*e*) The *Blanchard Ridge.**

- α. Its location.
- β. Its external form.
- γ. Its contents.
- δ. Its altitude above Lake Erie.
- ε. Its origin.

(*f*) The *Belmore Ridge.*

- α. Its location.
- β. Its external form.
- γ. Its contents.
- δ. Its altitude above Lake Erie.
- ε. Its origin.

III. The Lacustrine Area.

(*a*) Evidences of submergence, — their altitude.

- α. "Limestone ridges."
- β. Ozars.
- γ. Laminated clays.
- δ. Cause of this submergence.
- ε. The presence of the glacier.

IV. Glacier Marks, — their Direction.

V. No evidence of the Champlain Epoch.

VI. No evidence of the Terrace Epoch.

* In the Ohio Geological Reports for 1871, this ridge is named the *Leipsic Ridge*, because of its chief development and favorable exposure in sections by the operations of the railroad at that place, in Putnam County, Ohio. But observations made in the season of 1872 proved that its development there was confined to the inner margin only of a greater and wider moraine, which deflects the Blanchard River from flowing north direct to Lake Erie; and the name *Blanchard Ridge* has been substituted to cover the whole moraine.

I. The Character of the Drift in General.

(a) *Where consisting entirely of Hardpan.*

In general, it is true to say that *North-Western Ohio is covered with hardpan drift.* It lies on the rock, and it rises to the surface forming the soil. Wells penetrating it get no water, except from seepage, before reaching the stratum of gravel which often intervenes between it and the rock. Its thickness varies from twenty-five to one hundred feet. It is impervious to water, and serves in many instances as the confining stratum for the water of artesian wells. The slope of the surface being very gradual, and uniformly toward the main axis of the Lake Erie valley, such artesian wells are found in many widely separated parts of the district under consideration. The water rises generally not over ten feet above the surface, and proceeds from the depth of fifty to a hundred feet. This hardpan drift lies like a thick and heavy mantle on the rocky surface, covering it from sight to the height of over six hundred feet above the level of Lake Erie. It extends to and beyond the water-shed between Lake Erie and the Ohio River; but toward the south it becomes more gravelly and gives place to knolls and ridges, which consist mainly of stratified materials. While the mass of the hardpan is clay, it embraces great quantities of stones, gravel and boulders. The boulders, although not wanting at any horizon in the mass, are yet more abundant near the bottom. They are generally of foreign origin, embracing representatives of the Huronian, Laurentian, and trappean rocks of Canada and Northern Michigan; but they are apt also to consist largely of fragments from the rock *in situ.* It has been observed that, while the former are scattered throughout the hardpan from top to bottom, the latter are usually seen only near the bottom, or in such positions as to leave no room to doubt that they lay originally below the hardpan, or near its base, and have been made to appear superficial by the removal of the clay and overlying drift. They are all apt to show one or more glaciated surfaces.

Sometimes, in penetrating this hardpan deposit, isolated, lenticular beds of assorted materials are met before reaching the bottom. They are also occasionally seen in the banks of streams, where a fresh section may show a handsome oblique stratification of gravel

or sand. Such beds of stratified materials, embraced in the hardpan, are more and more frequent toward the south, or in those regions contiguous, east, west, or north, which have a rougher rock surface, or which rise too high to have been subjected to the same forces as those which operated to bring about the surface features of the Fourth District.

(*b*) *Where the Surface is laminated.*

In some parts of the Fourth District, the limits of which are not yet accurately ascertained, the surface of the drift is finely laminated in horizontal strata. These stratified beds have sometimes a thickness of over twenty-five feet, but are not known to exceed thirty. They consist principally of fine clay and sand. The layers of clay may be three or four inches in thickness, but the layers of sand are generally less than an inch. It seems difficult in some instances to determine the thickness of either the clay or the sand beds, one passing into the other with imperceptible changes. These beds embrace no boulders, stones, or gravel. Their junction with the hardpan below is marked by irregularities. The stratification becomes oblique instead of horizontal. It is sometimes wavy and curled, the beds being wrapped about and in other ways enclosing small masses of hardpan containing gravel and stones. Sometimes the hardpan rises suddenly in the midst of this stratification, nearly or quite to the surface of the ground, the beds showing but little distortion, but losing themselves gradually in the confused mass. This condition of the surface of the drift in North-Western Ohio prevails along the main watercourses, like the Maumee and the Sandusky Rivers. It is beautifully exposed at Toledo, where the steam dredge has made a way for the steam car into the city from the north. It is also exposed in the "Blue Banks," near Fremont, as well as at numerous other places along the banks of those rivers. This is not the uniform, nor even the usual, condition of the surface of the drift even along the main drainage valleys; and at places remote from these streams it is apt to be altogether wanting, the hardpan rising to the surface.*

* For detailed descriptions and sections illustrating the junction of the stratified with the unstratified drift, see the Ohio Geological Reports, under "The Drift in North-Western Ohio," 1871.

(c) *How the Hardpan was deposited.*

This of course is a subject of speculation and hypothesis, but it has been the source of some of the warmest discussions in strictly scientific circles during the past forty years. The glacier hypothesis of Professor L. Agassiz is however now very generally accepted by geologists, especially of the younger class; and it is the only hypothesis which will account for the surface geology of North-Western Ohio. The action of the glacier has been invoked to account for the glaciated surface of the rock, and to some extent for the transportation of northern boulders. The present condition of the drift, however, has been ascribed to a subsequent submergence beneath an ocean, or inland lake of fresh water, with imaginary boundaries and fictitious barriers. Over this sea, icebergs floated, bearing the materials of the vast drift-sheet, which being dropped in the waters are supposed to have been distributed and arranged by waves and currents as we now see them. Omitting now various considerations which militate against the iceberg theory, it seems reasonable to suppose the grinding progress of the glacier would be ample to produce and to bear along the fine as well as the coarse portions of the drift.

Toward the close of the Glacial Epoch, after the great sheet of continental dimensions had retired from Ohio, leaving only the valleys and fiords filled with moving ice, it may be supposed that a local glacier filled and continued to pass up the St. Lawrence valley, deriving its origin and impetus from the Laurentian highlands of Canada. It is sufficient to say that it has been ascertained that the ice moved up that valley in the south-westerly direction, thrusting itself up on the northern slopes of the States of Ohio and Indiana. This valley properly embraces these slopes, and includes the areas of Lakes Erie and Ontario. The New England and New York highlands, with their north-eastern extension into New Brunswick and Nova Scotia, probably gave the impulse to the south-westerly flow of the ice, diverting it from its normal north-south direction. From the north it received constant additions, and it escaped in a southerly direction over its southern barrier wherever it could find egress. Some streams passed over New England, reaching the ocean; one went down the Lake Champlain and Hudson River valley; others dug the fiord lakes in Central New York; one excavated deep the Cuyahoga valley; but the

foot of the main mass of ice was protruded up into the *cul-de-sac* of the Maumee valley, where no shale-beds existed to permit the excavation of narrow lakes or deep river channels. Here, at this period of the ice age, its force was spent. Let us for a moment consider what would be the condition of such a moving, ploughing field of ice, but only in its relations to the drift which it bore along. Where was the detritus which subsequently made the hardpan? It cannot have been as a whole under the glacier, for the long uniformity of the glacier-marks points to the immediate presence of the graver in the form of a solid frozen mass, holding the boulders to their places. It must have been either frozen within the ice of the glacier, distributed through it from top to bottom, or it must have lain on the top. Fine dust and detritus will accumulate on the top of glacier ice even in the steep descents of the Alps, and on the *mer de glace* where no boulders can mingle with it. The violence of storms in those mountain regions is said to be very great, gusts of wind carrying dust and sand over the mountain ridges, and, sweeping through the valleys, strewing the surface with foreign matter. Were it not that this is annually covered with a new fall of snow, thus producing the alternations of dirt and ice, which have caused some discussion touching the internal structure of Alpine glaciers, we cannot say how thick the dirt accumulated would not become. Reference may also be made to the occurrence of "sand pyramids" on the surface of Alpine glaciers described by Professor L. Agassiz. Now the St. Lawrence glacier differed from Alpine glaciers, and from all glaciers that have been studied by man, in two very important particulars: 1st, Instead of passing down steep descents, by which the fine materials would be lost in the streams of turbid water which would run over it and from it, the St. Lawrence glacier ascended — at least after it received form and direction in the St. Lawrence valley — a gentle incline, and occupied a broad valley which received a number of streams carrying their own freshet *débris*. 2d, Instead of descending suddenly below the *level* of perpetual ice, and so thawing out rapidly, the St. Lawrence glacier passed southward beyond the *latitude* of perpetual glaciation, actually ascending instead of descending as it entered a warmer climate. These circumstances served to prolong the stream of ice, and to retain the finest parts of the drift. The surface of the glacier was the level of the country. The surface of glaciers in the Alps sinks away by the melting of the ice from five to ten feet annually. The St.

Lawrence glacier must have suffered in the same way. All accumulations frozen within the ice would therefore tend to become superficial, and to ride on the surface of the glacier. In that way it would become covered with a sheet of drift consisting both of fine and coarse materials in a confused mixture. Whatever may have been the position of this detritus in latitudes further north, for some miles before the ice-sheet became too attenuated to maintain its progress it must have been mainly on the top of the ice. As fast as the ice-sheet was contracted, this even spreading of unassorted drift was allowed to rest slowly down on the rocky surface, covering the glacial marks and preserving them from obliteration. Wherever water was sufficient to assort the drift in the act of deposition, the clayey constituents were washed out and beds of stratified gravel and sand were formed.

II. The Moraine Ridges.

In North-Western Ohio are six long and continuous ridges, popularly known and regarded as ancient *lake beaches*. They have a great similarity in form, direction, and sometimes in contents, to beaches; and their general conformity to the shape of the coast-line of the west end of Lake Erie probably suggested the beach theory for their explanation.

It must be admitted also that some geological observers and writers have accepted the beach theory of their origin, and have given them a place in the closing events of the Terrace Epoch. This, we believe, has been done inconsiderately. Sir Charles Lyell, in his "Travels in North America," was exceedingly reserved in his expressions of opinion as to their cause. Yet after making a traverse of similar ridges north from Toronto, he says: "The hypothesis which attributes such appearances to the successive breaking down of the barriers of an ancient lake or ocean of fresh water has now been very generally abandoned, from the impossibility of conceiving where in North America, as in the west of Scotland, the lands capable of damming up the waters to such heights could have been situated; or how, if they ever existed, they could have disappeared, while the levels of the ancient beaches remained undisturbed." He concludes by saying that he considers "the ridges and other marks of ancient water levels between Toronto and Lake Simcoe as referable, some of them, to ancient beaches and lines of cliff formed on the margins of channels of the sea; others, including

some of the loftiest ridges, as having originated in banks or bars of sand formed not at the extreme edge of a body of water, but at some distance from the shore, in proportion as the water obtained a certain shallowness by the upheaval of the land." Colonel Charles Whittlesey considers those ridges on the south side of Lake Erie, at Cleveland, and east of that city, as sand-bars formed by the joint action of waves and currents near the shore of that lake when it stood higher than it does now. Professor J. S. Newberry adopts the beach theory to explain these ridges, and regards them as evidence of extensive subsidence of the continent below the sea. Mr. G. K. Gilbert was the first, we believe, to question this explanation, and to suggest that two, at least, of the ridges in North-Western Ohio are caused by "buried terminal moraines."

During the season of field-work of 1871, and to the present time in the season of 1872, considerable attention has been given to the location, form, and contents of these ridges. They are fully and specially described in the Ohio Geological Reports, not yet published, with diagrams and sketches to illustrate the arrangement of the materials of which they are composed. At this time nothing can be given but a general description, referring to those reports for confirmatory details.

(a) *The St. John's Ridge.*

a. Its Location.

This is so named from the village of St. John's, in Auglaize County, where it has a remarkable development. It enters Auglaize County from the north-east, or rises so as to become distinguishable in the north-west quarter of Wayne Township. It continues in a south-westerly direction past the village of St. John's, crossing the Dayton and Michigan Railroad at Botkin's Station. The village of New Bremen is a little south of the summit of this ridge. Chickasaw and Carthagena are each about a mile north. It forms a barrier along the north side of the Wabash in the south-western part of Mercer County, preventing its direct flow northward till it finally passes the ridge at Fort Recovery. Further west, in Indiana, it is believed to govern the direction of the Salamoine River, although it has not been examined in that State. In Auglaize Township, Allen County, it seems to coalesce with the Wabash Ridge, the two producing what is known there,

and especially at Maysville, as *the great dividing ridge*, since it actually forms the summit of the watershed between Lake Erie and the Ohio River.

β. Its External Form.

In Allen and Auglaize Counties the external form of this ridge is that of a rolling and bluffy strip of land, rising from the level of the adjoining clay flats sometimes to the height of forty or fifty feet. In Shelby and Mercer Counties it is less noticeable, sometimes sinking away so as to be observable only by the use of the spirit-level. Its direction, however, even in these low places, is indicated by the line of gravel-pits which have been opened in the low mounds which it forms. Its width is generally about half a mile, but may be a mile.

γ. Its Contents.

It consists essentially of the coarser parts of the drift. The immediate surface, except in the most rolling parts, is of brown clay hardpan, which forms the soil, and differs very little from the subsoil of the flat tracts on either side. It is, however, apt to be more gravelly, and sometimes large stones and boulders are seen on the surface. Where the surface is very broken, it is very gravelly and even stony. This covering of hardpan is apparently thicker in the low parts of the ridge, or where it sinks away so as to be less noticeable. Below the hardpan, gravel and sand in oblique and handsome stratification are met with. In this gravel and sand are occasional places which show a mixture of gravel and sand, without stratification or assortment, yet with no clay. Sometimes also, in the midst of this confused mixture of gravel and sand, may be seen a collection of stones and boulders, from the size of a few inches in diameter to two or three feet. These may all be confined to the space of two or three cubic yards, and may have mixed with them some coarse gravel. They may hold any position in relation to the rest of the ridge and its contents. They may underlie or overlie beds of coarse or fine gravel or of sand, or mixed beds of coarse gravel and fine sand with no assortment. They have been seen sometimes to lie in a kind of wedge-shaped pocket, pointing upward, with alternations of beds of coarse and fine gravel or sand placed on either side, or on only one side, the latter showing some assortment and stratification. In rare instances, balls and irregular masses of hardpan clay of a foot or a

yard in diameter have been seen imbedded and embraced in beds of sand and gravel, which latter would in that case be generally stratified about, and accommodated to the exterior of, the hardpan mass. It is not known to what depth this gravel and sand extends. It at least is known to be the immediate cause of the ridge, since where it is wanting the ridge is low or almost lost. It is most likely, however, that a continuous deposit of the same kind of materials, in the form of a ridge, lies below the hardpan in the whole extent of the St. John's Ridge, resting on the rock, and that under favorable circumstances the deposition was greatly increased at certain places.

δ. Its Altitude above Lake Erie.

The following list of elevations above Lake Erie will convey a general idea of the height of the St. John's Ridge above that lake, and will show the variations of level to which it is liable. It must be admitted, however, that these figures require some allowance for the effect of railroad grading, and the uncertainties of single barometrical measurements. The altitude, 490 feet, at St. John's is considerably above the usual height of the ridge, since it there has a remarkable development.

Elevations on the St. John's Ridge above Lake Erie.

St. John's, summit of hill (G. K. Gilbert, by barometer)*	490 feet.
St. John's, main street, below the hotel, north of the hill	435 „
St. John's, surface of a little stream west of the village	394 „
[The last are by Locke's level from Gilbert. These three elevations are all within the village, and show an extreme difference of 96 feet between the base and the top of the ridge.]	
Botkin's Station, Dayton and Michigan Railroad	441 „
New Bremen, Miami Canal	386¾ „
New Bremen, Fremont and Indianapolis Railroad (J. H. Klippart)	465 „

Its average elevation in the State of Ohio seems to be about 425 feet above Lake Erie. Between St. John's and New Bremen it descends toward the west over one hundred feet.

* In August, 1872, this hill was remeasured by aneroid barometer connecting with the depot at Wapakoneta, with the following result: summit of the hill, 504 feet; street in front of the Bitler House, 483 feet; surface of stream west of the village, 393 feet.

e. Its Origin.

Astronomical causes, which have been ably discussed by Mr. James Croll, of Scotland, and by others, must have produced in the retreat of the ice of the Glacial Epoch a halting motion. At the time that the St. Lawrence glacier was hardly yet defined as an independent local stream of ice, even when the foot of the ice-sheet of perhaps continental width was situated where the St. John's Ridge runs, a period of greater cold supervened, causing a stop in the retreat of the ice-foot, and a consequent accumulation of the detritus which the ice brought forward, at that point. Now if it be remembered that whatever the condition of the climate, whether one of increasing warmth or of stationary temperature, the foot of a glacier must always give off water, the product of its own dissolution, it can easily be seen that all along the foot of the glacier in North-Western Ohio, where no inequalities in the rocky surface would have brought the water into valleys having a north-south direction, there would have been a constant, gentle discharge of water, which would have produced some effect on the drift. That effect would have been greatest where the water was most abundant. The effect of running water on a plastic mixture of clay, sand, gravel, and boulders, the materials of the glacial detritus, is necessarily to wash out the clay. If there be a slow and constant deposition of such materials at the same point, there will necessarily be a cleanly washed and assorted accumulation of such coarse materials as the water has not the force to carry away. These conditions are all fulfilled along the ice-foot, and they must have operated to produce the series of gravel knolls and ridges which have been named the St. John's Ridge.

Allusion has already been made to the remarkable development at this ridge at St. John's in Auglaize County. At that place there must have been an extraordinary flow of water. By reference to the geological map of the State of Ohio (not yet published) it will be seen that the *Niagara limestone* is suddenly protruded northward in the form of a narrow tongue or wedge-shaped area, covering the eastern portion of Auglaize and the south-eastern portion of Allen Counties. It occurs as an anticlinal, dipping to the east and west, and passing under the *Waterlime* in both directions. Compared with the Waterlime it is a more enduring rock, and everywhere in North-Western Ohio, as elsewhere, it is the most conspicuous member of the *Cliff Lime-*

stone Group, and forms the surface rock where it rises highest and is exposed most. The effect of such a persistent obstruction beneath the glacier must have been to fracture the ice profoundly, those parts toward the east and toward the west settling gently away from the uplifted centre. Into those crevasses the drift would fall, and through them streams of water would flow. The result would be an extraordinary accumulation of coarse and assorted drift materials, which, after the complete withdrawal of the ice, would lie in irregular knolls and short ridges in places where such streams formerly existed. This is the origin of a great many short but steep and narrow gravel ridges in the North-Western States, outside of Ohio, which are known locally as "Devils' Backs," or "Hogs' Backs." The writer has seen them in Jackson and Ingham Counties, in the State of Michigan, and in the valley of the Fox River, Wisconsin, south of Green Bay. There is a fine one in Auglaize Township, Allen County, Ohio, and a number in Taylor Creek Township, in Hardin County. They rise generally from twenty-five to forty feet, with slopes as steep as such materials can be piled. On either side there is usually a low, swampy tract, from three to ten rods wide, or sometimes of indefinite width and form, the ridge being in some cases not more than twenty feet across on the summit. The largest boulders are sometimes seen on the very top of the ridge. Similar short ridges have been described as occurring in the State of Maine.

It is proper to add to this description of the St. John's Ridge, that its normal direction is more south-easterly, and that its passage northward into Allen County and its apparent union with the Wabash Ridge, near Maysville, may be due to the disturbance caused by the underlying *Niagara*, its real existence and location further east in Logan and Union Counties being obscured by the advent of the *Corniferous* in Logan County, which operated in the same way as the *Niagara* in Auglaize County. A ridge of hard-pan drift crosses Union County between Mill Creek and Big Darby Creek. Newton, in Union County, is located on it. It contains little or no stratified gravel or sand, although it is penetrated often over sixty feet in digging wells.

(b) *The Wabash Ridge.*

a. Its Location.

This ridge is so named from the Wabash river which flows along the south side of it for several miles in Mercer County, Ohio, and in Jay County, Indiana. It crosses Mercer County, forming the north bank of the great artificial reservoir, to St. Mary's, in Auglaize County, where it is crossed by the St. Mary's River; thence north-easterly to section 29, Moulton, Auglaize County, where it is cut by the Auglaize River; thence still north-easterly to Maysville, it forms a barrier to the northward flow of the same stream; thence east and south-east it forms the north boundary of the Scioto Marsh, and a barrier against the Scioto River, through Hardin County. It then turns north-easterly, but its location is not evident through the township of Grand, in Marion County. It becomes conspicuous again as a barrier against the lower portion of the Little Sandusky River in Wyandot County, and along the north-west side of the Broken Sword Creek in Wyandot and Crawford Counties. In the north-eastern part of Crawford County it becomes lost in the general drift, — at least it has not been traced further east.

β. Its External Form.

Its surface is much less broken by knobs and bluffs than that of the St. John's Ridge. It rather has the appearance of a gentle swell in the general surface, or a great wave stretching across the counties from one to two miles in width. Sometimes, in approaching it, it is invisible to the eye, the ascent is so gradual; yet its geological and topographical characters are so uniform and persistent, that it serves to divert from their natural courses the principal streams of North-Western Ohio throughout a distance of about one hundred and fifty miles, leading them diagonally across the slope of the country; sometimes turning them from the Lake Erie Valley, across the great watershed of the State, into the Ohio River. Throughout this distance it is crossed by three streams, the St. Mary's, the Auglaize, and the Sandusky, but only after having withstood them till, on the principle of the Archimedes screw, they surmounted it diagonally.

γ. Its Contents.

At St. Mary's and near Wapakoneta, gravel is taken from this ridge; and it probably has a nucleus of gravel throughout its extent, although it shows far less gravel than the St. John's Ridge. It everywhere consists superficially of the common hardpan of the country. Wells have sometimes penetrated it a hundred feet, passing through the brown and blue hardpan only, and obtaining very little water. It is probably due to its clayey nature that it operates so effectually in governing the direction of the drainage of the country. It is noticeable that it is only known to contain gravel where it is crossed by the St. Mary's and Auglaize Rivers.

δ. Its Altitude above Lake Erie.

The following points of elevation on the Wabash Ridge indicate its average height in Ohio to be about 360 feet above Lake Erie. If the doubtful elevation at Celina be discarded, this ridge shows a descent toward the west, between Kenton and St. Mary's, of forty-seven feet.

Celina (J. H. Klippart)	395	feet ?
Wapakoneta (two miles north), Dayton & Michigan Railroad	350	„
Wapakoneta (two miles north-west on the ridge), aneroid from depot	348	„
St. Mary's (by the Miami Canal, plus thirty feet)	321	„
Maysville, Hardin County (one mile south)		„
Kenton (two miles north), C. S. and C. Railroad	368	„

ε. Its Origin.

The origin of this ridge must have been the same as that of the St. John's Ridge; yet it is evident the ice was giving off far less water than during the formation of that ridge, leaving the drift brought forward by the glacier very nearly as it existed on the ice before deposition on the rock. It marks a period either of absolute rest in the amelioration of the climate, when the ice-foot was stationary for a long time at the same latitude, or a short recurrence of greater cold, when the ice-foot was thrust further south, ploughing up the drift before deposited, and heaping it into a long ridge or moraine. The latter supposition would account for a feebler flow of water.

(c) *The St. Mary's Ridge.*

a. Its Location.

This ridge is named from the St. Mary's River, the course of which it determines for more than fifty miles, nearly thirty of which are in the State of Ohio. In the same manner it prevents the St. Joseph River from taking its most direct course to the Maumee Valley for about the same distance. They crossed it only at Fort Wayne, Indiana, where their united waters, coming from opposite directions, broke through the barrier, the resulting river taking the name of Maumee, and returning between the St. Joseph and St. Mary's in a direct course to Lake Erie. The St. John's and the Wabash Ridges have not been traced and located, and probably cannot be, in their north-westward course in Indiana and Michigan. The *great* field of ice then probably covered the whole country north of those ridges, the St. Lawrence glacier not yet having taken independent direction. But when the St. Mary's Ridge was laid down, the foot of the St. Lawrence glacier had become defined as an independent margin, progressing and retreating according to the conformation of the great valley it occupied, and the climatic influences on the great ice-field further north which fed it. Hence we find it shaped with a certain relation to the present Lake Erie coast, and conforming to it in its main outline, even into the State of Michigan. Its location through Defiance and Williams Counties was ascertained by Mr. G. K. Gilbert, formerly of the Ohio Geological Corps, in 1869 and 1870. It is cut by the Miami Canal about two miles south of Spencer, in Allen County, the excavation being known as "the big cut." It thence turns a little north-easterly, and is passed by the Auglaize River near Fort Amanda. It is also crossed by the Ottawa River, about four miles south-west of Lima; thence north-east it forms a barrier to the Ottawa River, to the county line between Allen and Hardin Counties; thence easterly it passes along the north side of Hog Creek Marsh, and about a mile south of Williamstown, in Hancock County. East of Williamstown its location is not known with certainty; but it probably runs more north-easterly from this place, along the north-west side of the Tymochtee Creek to its junction with the Sandusky, to McCutchenville in Wyandot County, and Melmore in Seneca County.

β. Its External Form.

The form of this ridge is very similar to that of the Wabash Ridge. It is like a dead wave on the surface of the ocean, hardly perceptible to the eye on account of its smoothness, but revealed by its effect on every thing that encounters it. It is most noticeable in Mercer County, and in the State of Indiana, where it forms a very prominent ridge, having a width of half a mile or more.

From Fort Wayne, Indiana, eastward, the St. Mary's Moraine has a V shape, the apex pointing toward the west, one arm lying along the north side of the St. Mary's River, and the other passing more eastwardly through New Haven (a quarter of a mile south), a little south of Besançon, and entering Ohio in the south-west quarter section 31, Benton, Paulding County, about half a mile south of the Van Wert Ridge. Thence south-eastwardly, the north margin of the St. Mary's Moraine runs through Convoy, in Van Wert County, and through sections 17, 18, 22, and 23, in Pleasant Township, in the same county, beyond which place it has not been identified. This north margin of the St. Mary's Moraine is very noticeable about Fort Wayne, and as far east as Tully Township, in Van Wert County. It gradually loses its distinctness in passing toward the east. It consists, like the south margin, of hardpan drift, differing in no respect from the common drift of the whole district. Its descent toward the north is sudden, and in amount from five or six feet south of Van Wert, to ten feet in Tully Township, south of the Bear Swamp, and thirty feet at New Haven, Indiana. At Fort Wayne its junction with the south arm of the V between the St. Mary's and Maumee Rivers gives rise to a very greatly increased elevation. It is there over forty feet, and appears like an old bank of the Maumee River. Indeed, the impression prevails that it is an ancient river-bank, and the land lying between the foot of this bench and the brink of the real river bank is known as the "second bottoms," the "first bottoms" being the flat loamy land immediately bordering the river, and marking the height of the extreme freshet floods. The "first bottoms" consist of sandy loam, with much decomposing vegetable material, the alluvium of the stream; but the "second bottoms" lie twenty to twenty-five feet higher, and consist of hardpan clay, the soil being heavy and stiff. The exposed sections of the river bank reveal the contents of the "second bottoms," wherever the "first bottoms" are wanting. At Fort Wayne a fresh section of

the "second bottoms" on the right bank of the Maumee, shows the peculiar characters of the hardpan drift already described. This bench, which forms the inner margin of the St. Mary's Moraine, rises still higher; and instead of following the course of the stream, of which it is popularly supposed to be an old bank, it strikes out at a considerable angle away from the river, gradually fading out till it is lost. South of Van Wert, where it reaches its most eastern observed point, it is more than thirty miles from the Maumee River in a direct line, and ninety-seven feet above it. South from the summit of this bench the surface has no descent, but spreads out in a vast table-land, on which are sometimes extensive prairies and swamps. The bench itself is sometimes known as a ridge. Indeed, the "ridge road" uniting Fort Wayne and Van Wert sets out on it from Fort Wayne, following it about ten miles, when it changes to the *Van Wert Ridge*, which lies nearly parallel and about a mile further north. It passes from one to the other two or three times between the two cities. On the north side of the Maumee a similar bench occurs, descending to the south-east, having about the same height as on the south side. Toward the north spreads out a flat of clay land, with a little descent to the north. This flat extends as far as to the St. Joseph River, where the outer periphery of the same great moraine sets against the waters of that stream. This moraine here also has a V shape, but with a sharper apex, which lies at Fort Wayne, between the St. Joseph and the Maumee, the arms extending north-eastwardly. No detailed examination has yet been made of this moraine north of the Maumee River.

γ. Its Contents.

A little gravel is taken from this ridge near Lima and near Shanesville; but it consists for the most part of hardpan. It shows nothing but hardpan, with stones and boulders in wells which penetrate it. The common gravelly hardpan soil forms the surface. It consists of hardpan only, to the depth of twenty feet, where the Miami Canal cuts it near Spencer. It rises in conspicuous hardpan hills near Fort Wayne, Indiana, east of the depot of the Toledo, Wabash, and Western Railway.

δ. Its Altitude above Lake Erie.

The following points of elevation on the St. Mary's Ridge have been ascertained. The lowest point on the ridge is at Fort

Wayne, Indiana, where it has its greatest distance from Lake Erie. It rises in both directions from that point. In this respect it corresponds with the St. John's and the Wabash Ridges. Their lowest places are in the axial line of the great valley which they diversify.

ELEVATIONS ON THE ST. MARY'S RIDGE ABOVE LAKE ERIE.

Hudson, Michigan, L. S. and M. S. Railroad	354	feet.
Crossing of the Air Line of L. S. and M. S. Railroad, west of Bryan	300	„
Crossing of Baltimore and Ohio Railroad, west of Bryan (S. W. Hartwell, C.E.)	329	„
Fort Wayne, Indiana, Depot Toledo, Wabash, and Western Railroad *	204	„
Fort Wayne, summit of moraine, one mile east of depot (Aneroid)	229	„
Fort Wayne, two miles east of Toledo, Wabash, and Western Depot (Locke's level from Railroad)	246	„
Fort Wayne, two miles east of Pittsburg, Fort Wayne, and Chicago Depot †	237	„
Spencer, two miles south (Miami Canal, plus twenty-five feet)	299	„
Lima, two miles south, Dayton and Michigan Railroad . .	322	„
Hog Creek Marsh, north one mile (Aneroid) †	341	„

e. Its Origin.

This ridge must have been formed by the motion of the St. Lawrence glacier and the deposition along the foot of an increased amount of glacial drift, during a period of greater cold than that immediately preceding, so that its margin remained stationary at nearly the same point for a long period of time. The preponderance of the south-westerly motion over the southerly, according to the direction of the great valley, is here first observable in the greater development of this moraine about Fort Wayne than at points further east.

(*d*) *The Van Wert Ridge.*

a. Its Location.

This is so named from the city of Van Wert, Ohio, through

* The profile of the Pittsburg, Fort Wayne, and Chicago Railroad makes the Union Depot at Fort Wayne thirty-one feet higher than the Toledo, Wabash, and Western.

† This is from the level of the Pittsburg, Fort Wayne, and Chicago Railroad, reduced to the base line of Lake Erie, according to the profile of the Toledo, Wabash, and Western Railroad.

which it passes. It enters Ohio from the north, in the north-west corner of Fulton County, with a course nearly south-west. It passes through West Unity, Bryan, Williams Centre, and Hicksville; and entering Indiana it may be traced, by way of Maysville, to a point on the north side of the Maumee River, about three miles below Fort Wayne, where it is intersected by that stream. It reappears on the south side about three miles north-east of New Haven, Indiana. West of that point, to its intersection by the Maumee, it is buried in lake sand, and its location is entirely lost. It is here known as the *Irish Ridge*, and for about a mile a road runs on it. It soon enters an undeveloped tract of country, no road following it, but by careful search it has been followed connectedly for a distance of six miles east from New Haven. It is then known to pass along the south side of the Bear Marsh, both in Indiana and Ohio, a distance of ten or fifteen miles. In Van Wert County a public road is located on it, passing through Van Wert; although the road in some places leaves the Van Wert Ridge, and runs on the north margin of the St. Mary's Moraine. Thence east this ridge passes through Delphos, Columbus Grove, Pendleton, Webster, and Benton, nearly to Findlay, where its identity is lost in the succeeding Blanchard Moraine.

β. *Its External Form.*

This is the outer of those two ridges described by Mr. G. K. Gilbert in the May number of the "American Journal of Science and Arts," in 1871, and regarded by him as ancient lake beaches. Its form differs considerably from those ridges already described. While it has as much gravel as the St. John's Ridge, or perhaps more, in proportion to its size, it is much narrower, and has little or no influence in determining the direction of streams. In this respect it differs from the Wabash and St. Mary's Ridges even more than it does from the St. John's Ridge. It rarely presents a greater width than fifteen rods, while it usually is not over five. It has a remarkable uniformity of contour, size, and direction. It has a gentle slope from the summit in opposite directions, and its height is usually about twelve feet. It is crossed by streams at various angles, and in all its course it is not known to deflect any river or creek from the most direct descent over the general slope of the country. Wherever it is crossed by a stream, it sinks away for some rods, or for a mile or two on either side, before reaching the banks. It cannot be found in either direction, above or below;

but it simply settles away slowly into the flatness of the surrounding country. The road, instead of being gravelly, becomes heavy with a tenacious clay.

In a number of places this ridge is doubled for a few miles, the two parts each having as great a development and uniformity of size and direction as the main ridge, where it consists of a single eminence. This is the case on the north side of the Maumee, near its intersection by that river. It is not known how far the two parts run as independent ridges toward the north-east, but they are each well developed for some distance from the river. At that place the Maysville "ridge road" is located on the inner ridge, or that most distant from the inner margin of the St. Mary's Moraine. Yet on the south side of the Maumee, in Van Wert County, the road is generally on the outer of these ridges, wherever it is doubled, or on that one nearest the inner margin of the St. Mary's Moraine. Where the Van Wert Ridge consists of two parts, the subordinate member rises and falls independently of the other, and has never been known to blend with it. They are usually separated less than half a mile, and have been noticed not to run strictly parallel.

γ. Its Contents.

The Van Wert Ridge consists emphatically of gravel and sand, embracing the coarser parts of the drift, as stones and boulders. The great bulk of the whole is gravel, in handsome oblique stratification. Boulders are rarely found. In a few places also the ridge has been penetrated to the depth of over thirty feet without meeting much gravel. In those cases the common hardpan only is passed through, as in wells on either side of the ridge. Generally, gravel is met within two or three feet of the surface. Hundreds of little excavations have been seen by the road-side, in this ridge, for the use of the fine gravel it affords. It usually extends not over fifteen or twenty feet in depth. Immediately below it, the common hardpan of the country is met. If wells find no water in this gravel, they are necessarily sunk below the hardpan, sometimes more than forty feet. Lying on the gravel, and forming the immediate surface of the ridge, is a gravelly hardpan, which is almost impervious to water, and becomes compact and stiff if used for a public highway. Hence, as the gravel lies in a slight depression in the general surface of the hardpan, it is enclosed in a covered trough, and acts as a vast natural tile-drain to collect

and hold the surface water. Hence it is that this gravel is found almost invariably to contain water at the depth of less than ten feet. Hence it is also that artesian wells are sometimes obtained along the sides of the ridge by penetrating the impervious covering of the gravel, although sometimes not more than three or four feet.

δ. Its Altitude above Lake Erie.

POINTS ON THE VAN WERT RIDGE.

Gorham Township, Fulton County (J. H. Klippart)	220 to 225	feet.
West Unity, Williams County (J. H. Klippart)	230	„
Pulaski, Williams County (J. H. Klippart)	200	„
Bryan (Air Line Railroad level)	196	„
Near New Haven, north side of the Maumee (Aneroid from Railroad)	202	„
Near New Haven, "Irish Ridge," at crossing of Toledo, Wabash, and Western Railroad	195½	„
Van Wert, Van Wert County (Pittsburg, Fort Wayne, and Chicago Railroad)	218	„
Delphos (Pittsburg, Fort Wayne, and Chicago Railroad)	211	„
Columbus Grove (Dayton and Michigan Railroad level)	194	„

This ridge, unlike the St. John's, Wabash, and St. Mary's Ridges, seems to lie nearly horizontal, showing very little descent on approaching the Maumee River. It is probable that the elevations, given above at West Unity and in Gorham Township, were taken from the inner margin of the St. Mary's Moraine, which rises about thirty feet higher than the Van Wert Ridge. For further notes on the relations of these two ridges in Defiance County, see the Geological Reports of Ohio, under "Geology of Defiance County." The average height of the Van Wert Ridge above Lake Erie is about two hundred feet.

ε. Its Origin.

It will be noticed that this ridge is but a short distance inside of the inner margin of the St. Mary's Moraine. Its sharpness, its narrowness, and its very gravelly character are features in which it strongly differs from it, and from the St. John's and Wabash Ridges before described. While the St. Mary's Ridge can unhesitatingly be ascribed to the retarded retreat of the ice-foot, thus heaping up a greater thickness of glacial drift throughout a belt about ten miles wide, the Van Wert Ridge seems to be due to a different kind of glacier-action. The ice-foot seems to have retreated sud-

denly, from one to two miles from the inner margin of the St. Mary's Moraine, when for some reason an unusual amount of water was precipitated from the ice on the already deposited drift along its margin, carrying away the finer materials not only from the upper portion of that which was already thrown down, but also from that being thrown down at that place. The gravel in the Van Wert Ridge lies above the great mass of hardpan, while the gravel of the St. John's and St. Mary's Ridges lies on the rock, with hardpan only above it. After this increased flow of water had spent itself, the ice-foot resumed again, or continued, its rapid retreat toward Lake Erie, throwing down a much thinner drift-sheet than it did on the outside of the Van Wert Ridge. This belt of thin drift covers the northern portion of Van Wert County and the whole of Paulding, as far as the Auglaize River, a distance of about thirty miles in the line of motion of the ice along the axis of the Maumee Valley. Further east this thin belt becomes narrower, tapering to a point absolutely (so far as it lies north of the Van Wert Ridge), at Findlay, in Hancock County. It is noticeable in Putnam County, where the drift south of the Blanchard River is less than half as thick as it is north of the same stream.

(e) *The Blanchard Ridge.*

a. Its Location.

This moraine is so named from the Blanchard River which it deflects from the most direct course to the Maumee, carrying it diagonally across the slope of the country, a distance of more than forty miles. In a similar manner it governs the direction of Bean Creek and Tiffin River, on the north side of the Maumee, making them flow south-west instead of south-east, the general slope of the surface being in the latter direction. It runs into Michigan, and Adrian is probably located on it. East of Findlay, Ohio, the direction of the Blanchard Ridge remains about the same, but it is not satisfactorily known through Seneca County. South of its intersection by the Maumee its inner margin is better known than its outer, and is often marked by a public road. It passes through Ayersville, where it is covered with later lake sand, south of the Medary Swamp, in Putnam County; through Leipsic Station, on the Dayton and Michigan Railroad, to McComb, Van

Buren, and Fostoria. It crosses the Sandusky River about a mile north of Tiffin. Further east it is not known.

β. Its External Form

Is similar to that of the St. Mary's Moraine: it is, however, not so evenly laid down. It is more frequently gravelly, and diversified with short, well-marked gravel moraines like the Van Wert Ridge. One in Putnam County runs north-westerly from near Gilboa for a distance of about five miles. There is a succession of such gravel ridges about Leipsic, and on all sides of the Medary Swamp in the same county. The inner margin of this moraine not infrequently has the form as well as the contents of a sharp, gravel moraine. It is so in many places between Van Buren and Fostoria, and east from Ayersville; but the width of the whole moraine is from six to ten miles, and its general surface is nearly flat. Its inner margin is more marked than the outer, the descent being so sudden that it constitutes a continuous shoulder in the surface, and often takes the name of *ridge*, its height being sometimes nearly twenty feet. In other places this descent is more gradual, and is broken up into a strip of rolling and gravelly land.

γ. Its Contents.

This ridge consists of hardpan drift, with those local modifications which were brought about by greater wash from the glacier at certain points or at certain times. It is on the whole, however, perfectly comparable to the St. Mary's Ridge already described.

δ. Its Altitude above Lake Erie.

The following points are located on its inner margin: —

ELEVATIONS ON THE BLANCHARD RIDGE ABOVE LAKE ERIE.

Section 18, Richland, Defiance County (Toledo, Wabash, and Western Railroad)	172	feet.
Leipsic Station (Dayton, and Michigan Railroad)	188	„
Fostoria (Lake Erie and Louisville Railroad)		
Fostoria (Baltimore and Ohio Railroad)	194	„
Fostoria (J. H. Klippart)	200	„
Watson's Station (C. S. and C. Railroad)		
Near Tiffin (J. H. Klippart)	210	„
Wauseon (Air Line of the L. S. and M. S. Railroad)	199	„

ε. Its Origin.

The Blanchard Moraine is believed to be due to the same cause as the St. Mary's and the Wabash Moraines. It is noticeable,

however, that the inner margin of this moraine is more marked, and traceable further east than that of the St. Mary's Moraine. Indeed its southern sweep in Ohio is much more prominent, especially, as already noted, on its inner margin, which is often thrown up in a conspicuous gravelly ridge, with a descent in both directions. The Maumee and the Sandusky are the only streams that cross it. Its marked development through the northern part of Putnam and Hancock and the central part of Seneca Counties seems to indicate an increase in the north-south force, while yet there is no noticeable loss of motion toward the south-west. In general this moraine has the same relation to the great St. Lawrence Valley, but it seems to have been crowded toward the south so as to absorb the eastern extension of the Van Wert Ridge which terminates in it at Findlay. These facts point to the probable existence of a contemporaneous glacier descending the Lake Huron Valley and crowding upon the foot of the St. Lawrence glacier, giving it greater development toward the south.

(*f*) *The Belmore Ridge.*

a. Its Location.

This is so named from the village of Belmore, in Putnam County, Ohio, through which it passes. South of the Maumee River, which crosses it in section 17, Richland Township, Defiance County, its position is well known; but on the north, through Defiance and Fulton Counties, its course is so near the inner margin of the Blanchard Moraine, and the two are so frequently covered with lake sand, that they have been separately identified in but few places. There is no doubt that in some places north of the Maumee they actually run together, the two forming a single ridge. This seems to be the case further north through Lenawee and Washtenaw Counties, in the State of Michigan. This ridge is first known, whether consisting of one or both, in the south-western part of Macomb County, in the State of Michigan. It passes through the village of Plymouth, is cut by the Huron River about two miles east of Ypsilanti, and continues to Ridgeville, in Lenawee County. A short distance south of Ridgeville it is covered with loose lake sand, from which it emerges and runs for some distance with perfect distinctness toward Lenawee Junction, in which locality it is again confused by the same means; and its point of exit from the State is not fully known. A ridge which superficially shows nothing but common hardpan appears in

Amboy Township, Fulton County, Ohio, entering the State from the north-east a mile and a half west of Metamora. It has not been traced connectedly to Delta, in the same county; indeed, perhaps could not be on account of the abundance of lake sand which is spread irregularly over much surface, but a similar ridge appears at Delta, and thence runs south-westwardly to West Barre, Ridgeville, and the point of crossing of the Maumee River in Richland Township, Defiance County. South of the Maumee it shows at once a tendency to duplication, one part running to Ayersville, and so on south-easterly, as already described, being the inner margin of the Blanchard Moraine; and the other running in about the same direction to Belmore, where the two ridges have their greatest separation, a little over four miles. East of Belmore, the Belmore Ridge runs separately to Pickensville in Hancock County, thence north-easterly in a line parallel with the inner margin of the Blanchard Moraine, and about three and a half miles north of it, to Eagleville in Wood County. East of Eagleville it has only been traced about five miles. Through Seneca County it has not been located, but it is probably the same as that known in the eastern part of Sandusky County and further east as the North Ridge.

β. Its External Form.

This ridge has the form of the Van Wert Ridge. Where it is distinct from the Blanchard Moraine, it is from five to ten feet high, and from six to fifteen rods over. It is generally very constant, and uniform in its height and direction, only disappearing, like the Van Wert Ridge, in the vicinity of streams. It offers little or no impediment to the descent of the surface drainage over the country in accordance with the principal slope. In some places it is better developed than in others, and gives rise to a broken surface which spreads laterally over a space of twenty or thirty rods. It has not been observed to be itself doubled; yet it has not been sufficiently examined to prove the contrary. It forms the foundation for a splendid gravel road, which is always dry even in the wettest seasons, when the clay roads adjoining on either side are absolutely impassable.

γ. Its Contents.

It consists of gravel, with occasional stones and boulders; yet in some places it is of hardpan. At Delta, on Mr. Spencer's farm,

it occurs as a low, inferior ridge, consisting more especially of stones and boulders, running near the base of the hardpan of the Blanchard Moraine.

d. Its Altitude above Lake Erie.

But few elevations have been obtained on this ridge, but enough to indicate its accord with the St. Mary's Ridge in being lower at the Maumee than at points further from the axis of that valley. Its average altitude above Lake Erie seems to be about one hundred and fifty feet.

ELEVATIONS ON THE BELMORE RIDGE ABOVE LAKE ERIE.

Two miles east of Ypsilanti, Michigan (Ypsilanti Station, 155 ft. + 15 ft., Michigan Central Railroad)	170 feet.
Lenawee Junction (L. S. and M. S. Railroad)	142 „
Lenawee Junction (by the preliminary survey of 1887)	154 „
Delta, Fulton County, Ohio (Air Line of L. S. & M. S. Railroad)	145 „
Three and a half miles east of Defiance (Toledo, Wabash, and Western Railroad)	166 „
Belmore (Dayton and Michigan Railroad)	160 „

e. Its Origin.

It will be noticed that this moraine follows a great moraine in the same way as the Van Wert Ridge. In both cases the great moraine which precedes consists almost entirely of hardpan, with gravel and stratified deposits buried deep. It is true also that in both cases the gravel moraine which closely follows consists of stratified gravel overlying the principal mass of the hardpan. They seem not only to have a similar relation to the great moraine preceding, but also to have had a similar origin. No such sharp gravel ridges follow the St. John's and the Wabash Ridges. The intervals by which the St. John's, the Wabash, and the St. Mary's Ridges are separated are very nearly equal. The occurrence of these gravel moraines indicates the advent of a disturbing element in the hitherto regular halts of the ice-foot. The retreat which followed the first amounted to about thirty-five miles before another period of cold intervened to bring on another great moraine. The retreat of the ice-foot, after the second gravel moraine (the Belmore Ridge) was formed, was continued beyond the limits of Ohio before another halt occurred, and its location is not known. The observed intervals then are about as the numbers:—

$$15 : 15 : 2 : 35 : 3\tfrac{1}{2} : x.$$

III. The Lacustrine Area.

(a) *Evidences of Submergence,—their Altitude.*

That considerable portions of North-Western Ohio, North-Eastern Indiana, and South-Eastern Michigan have been submerged since the deposition of the hardpan drift, cannot be denied. There are evidences of the presence of Lake Erie scattered over a wide tract, up to an altitude of two hundred feet above its present level. Mr. G. K. Gilbert has, in the article already referred to, fully demonstrated that the outlet of Lake Erie was at one time through the valley of the Wabash, the limestone rim of Niagara, at Huntington, Indiana, then setting limit to the height of its waters. Over that barrier it was compelled to pass. The evidences of its extending to that elevation consist of:—

a. "*Limestone Ridges.*"

These are slight eminences consisting of the limestone rock of the country, rising a few feet above the general surface, from which the drift has been entirely washed off, leaving the rock bare, and wrought into those fantastic forms which result from the breaking of waves and the action of frost on all rocks along the shores of the lakes or of the ocean. These ridges are most common in Wood, Sandusky, Seneca, and Lucas Counties, all lying within the last of the moraine ridges. About these ridges boulders of northern origin are very abundant. While they may be found occasionally in all parts of the district under consideration, lying on the surface, they are by no means common. Their specific gravity alone would carry them to the bottom of a plastic mass like the drift-sheet, when undergoing the mixing motion incident to the movement of the glacier. They are found to prevail specially at the bottom of the hardpan, although they are found throughout that deposit from bottom to top. When the gentle action of water and winds was brought to bear on this deposit, which may have been at the moment of its deposition by the glacier, the easily transportable parts were sifted out and carried away to be deposited by constant currents in horizontal laminations over the adjoining surfaces, or by the buffeting of waves, in the absence of constant currents, to be piled up as bars and beaches near the margin of that overspreading sheet of water. In this

manner the prominent places were levelled off, and the low places were filled up. In the former, the immovable boulders were left on the surface of the denuded rock; in the latter, the surface was covered with a very fine laminated sand and clay, or with massive banks of beach sand with no visible stratification. The boulders on these "limestone ridges" are very often grouped about the base of the ridge, encircling it in a belt, with very few lying on the top.

β. Ozars and Beaches.

North-Western Ohio, although in general a vast level tract, yet has undulations of surface due primarily to the form of the surface of the rock underlying, which may be invisible to the eye of the traveller, after the spreading of the drift, but which would cause shallows and sand bars to diversify the lake bottom. These and the moraine ridges would be the first barriers to the unbroken advance of waves. There are many places where the latter have formed the nucleus for the accumulation of drifting sand, and, by the constant breaking of waves, for the formation of ozars. There are others where they seem to have served for some time as beaches for short intervals. Accumulations of light yellow sand, in the form of knolls from five to fifty feet high, are found throughout the country up to the height supposed to have been the limit of Lake Erie. These sand accumulations sometimes take the form also of long ridges, which have a rough, undulating exterior, and run for a number of miles in the same direction. They are found, however, to have no uniformity of direction among themselves except when their *nuclei* first had such uniformity. Such sand is very often accumulated to an astonishing amount on the tops of the limestone ridges; the boulders round the base, and perhaps an exposure of the rock *in situ*, indicating the cause of the accumulation. In character this sand is loose, homogeneous, and yellow. It contains no gravel, boulders, or coarse materials of any kind, except where they have been forced upon it by other means, and shows no stratification. Sometimes, especially in the vicinity of the Maumee River, in Henry County, and also throughout much of Fulton and Defiance Counties at points remote from that river, it is spread very evenly over the surface, covering many square miles. In the case of the limestone ridges, when sand covers them, the trailing of the sand shows the resultant of all forces acting upon it to have been toward the south or south-west.

γ. Laminated Clay.

As has already been remarked, in some parts of the district under consideration, and notably along the Maumee River, and at some places along the valley of the Sandusky River, the great sheet of hardpan is overlain by a laminated clay, which contains no boulders and no gravel. Although the denudation of the prominent parts of the original drift surface by the action of waves and currents may have supplied material for some portion of this laminated deposit, yet it is not believed to have been the source of the greater portion. The location of the principal portion of these laminated clays along the drainage valleys, — as the Maumee and the Sandusky, — as well as their thickness and extent, will not admit of their reference to those accidental and often remote and isolated denudations. This lamination is believed to be due to the action of those streams on the drift at the moment of its deposition. When the foot of the St. Lawrence glacier stood at Fort Wayne, the escaping water must have had little or no effect in spreading the drift laterally in the form of laminations over the surface, the outlet being, probably, at that time, through the valley of the Wabash. The St. Mary's River — and the St. Joseph also, if it may be supposed then to have had an existence — would find easy escape through the same channel, and there would be but little standing water in the form of a lake to act on the drift at that point. Hence these surface laminations have not been seen at Fort Wayne; on the contrary, the immediate banks of the Maumee consist there of the typical hardpan. When, however, the ice-foot had retreated to Defiance, and there halted for a period of time, the action of the rivers, coming from higher land, and uniting there to form the beginning of Lake Erie, and especially of the Auglaize and Tiffin, would be to stratify the surface of the drift along the margin of the ice. The only portion of the St. Lawrence Valley not then filled with glacier-ice would be that portion between Defiance and Fort Wayne. It was probably to a great extent filled with the water brought in by the St. Mary's, St. Joseph, Auglaize, and Tiffin Rivers. Its outlet must still have been by the Wabash Valley. It is a fact that at Defiance, and over a belt five or six miles wide running north and south from that city along the outside of the great Blanchard Moraine, the surface of the drift is finely assorted and laminated, the resulting clay being too fine for easy agriculture. There are here also evi-

dences of beach action in the form of yellow sand. In some places along the Tiffin River this light sand shows an oblique lamination due to currents. Indeed, there are very slight changes and insensible gradations, seen in travelling over the country near Defiance, in the characters of these two deposits, the fine tough clay sometimes becoming a little sandy, and making a fine loam; the loam finally acquiring gravel stones, and passing into a hardpan soil again. These instances of the blending of the characters of these three separate features of the drift show the narrowness of the field in which the different forces producing them were confined. The glacier was bringing forward the crude *débris* of the hardpan. The Auglaize and the Tiffin were busy with their freshet currents in carrying off the fine parts to spread them over the surface of the drift already deposited, and the standing water of the lake was buffeting with its waves against the work of both, and covering them with fine sand, or mixing them all so as to make each almost unidentifiable. Below Defiance, at Perrysburg and Toledo, the action of the Maumee alone is seen in the same kind of laminations. At this time the lake must have been lowered by some other outlet, so as to give the Maumee a chance for existence.

δ. Cause of this Submergence.

It is easy to see the cause of this submergence of North-Western Ohio below the water of Lake Erie, in the freezing up of all its other outlets. It is a fact that the present outlet of the St. Lawrence Valley is far to the north; and it is reasonable to suppose that the hold of the glacier on those outlets would be last relinquished. Mr. M. C. Read, of the Ohio Survey, has suggested an ancient outlet of Lake Erie through Central Ohio. Its altitude compared with that through the Wabash Valley is not known. It is furthermore evident that the level of the lake would not be stationary at any point for a long period. If it depended on the shifting of the ice at its outlet, it would be likely to rise and fall according to the severity of the climate. This will account for the absence of well-marked beaches.

In the same manner the former outlet of Lake Michigan through the valley of the Des Plaines River must have been due to the occupancy of its present outlet, through the Straits of Mackinaw, by the ice of the retreating glacier.

IV. Glacier Marks, — their Direction.

In every case observed, the direction of glacier scratches coincides with and corroborates the supposed motion of ice up the Maumee Valley.

Within the Blanchard Ridge.

Location.	Formation.	Direction.
South-east end of Put-in-Bay Island	Waterlime.	South 62° west.
Half mile north of Genoa, Ottawa County.	Waterlime.	South 60° west.
West line of Sandusky County, bed of Portage River.	Waterlime.	South 58° west.
Sect. 9, Harris, Ottawa County.	Waterlime.	South 18° west.
South-west quarter Sect. 35, Jackson, Sandusky County.	Waterlime.	South 55° west.
South-west quarter Sect. 19, Pleasant, Seneca County.	Niagara.	South 56° west.
Sect. 29, Pleasant, Seneca County.	Niagara (dip north-east 10°).	South 44° west.
North-west quarter Sect. 7, Portage, Wood County.	Waterlime.	South 50° west.
North-west quarter Sect. 12, Freedom, Wood County.	Waterlime.	South 50° west.
South-west quarter Sect. 9, Freedom, Wood County.	Waterlime.	South 50° west.
South-east quarter Sect. 30, Freedom, Wood County.	Waterlime.	South 50° west.
Otsego, Wood County.	Lower Corniferous.	South 65°—68° west.
Otsego, Wood County.	Lower Corniferous.	South 68° west.
Otsego, Wood County.	Lower Corniferous.	South 60° west.
Whiteford, Monroe County, Mich.	Waterlime ?	South 81° west, & south 90° west.

Between the Blanchard and the Van Wert Ridges.

Findlay, Hancock County.	Niagara (slope east 30°).	South 45° west.
Findlay, Hancock County.	Niagara (level surface).	South 40° west.
Findlay, Hancock County.	Niagara (in the Blanchard R. level surface).	South 40° west.
Sect. 30, Blanchard, Putnam Co.	Waterlime.	South 28° west.
Sect. 13, Sugar Creek, Putnam Co.	Waterlime.	South 50° west.
Sect. 31, Auglaize, Paulding County	Upper Corniferous.	South 48° west.

Between the Van Wert and the St. Mary's Ridges.

North-east quarter Sect. 23, Seneca, Seneca County.	Waterlime.	South 5° east.

Note. — These marks are crossed and erased by the next.

Location.	Formation.	Direction.*
North-east quarter Sect. 28, Seneca, Seneca County.	Waterlime.	South 28° west.
Sect. 1, Amanda, Hancock County.	Niagara.	South 82° west.
North-west quarter Sect. 34, Crawford, Wyandot County.	Waterlime.	South 20° west.
Sect. 24, Crane, Wyandot County.	Waterlime.	South 5° west.
Sect. 15, Amanda, Allen County.	Waterlime.	South 35° west.
Between the St. Mary's and the Wabash Ridges.		
Sect. 18, Marseilles (west of the village), Wyandot County.	Niagara.	South 10° west to south 10° east, some being due north & south.
Between the Wabash and the St. John's Ridges.		
North-west quarter Sect. 26, Grand Prairie, Marion County.	Upper Corniferous.	North and south.

V. No Evidence of the Champlain Epoch.

Above the altitude of the outlet by way of the Wabash Valley, the writer has seen no evidence of submergence below Lake Erie. The laminated clays, the denuded rock surfaces, and the superficial yellow sand, are entirely wanting above about two hundred feet. The drift shows its glacier origin, as already explained, without the modifying action of lake water. If the *Champlain Epoch* can be understood to mean the submergence of certain portions of the St. Lawrence Valley incident to the blocking up of its northern outlet by the retreating foot of the glacier, it is necessary to admit its existence in North-Western Ohio. But it is believed those who advocate the Champlain and Terrace Epochs, and who would spread them over the whole north-west and the continent, will not agree to that circumscribed limit. By them it is believed the continent has been submerged, in some places by fresh water, and in others by salt, subsequent to the deposition of the drift; and that the prevailing waters acted on the drift, assorting and arranging it as we find it. Others ascribe the origin of the drift directly to this submergence, supposing it to consist of stratified clays through-

* All these observations may be corrected to the true Meridian by deducting 2° 15′ easting, that being the average variation of the needle in North-Western Ohio in the summer of 1871.

out. Others imagine icebergs floating over this lake, freighted with stones, boulders (and clay?), to have brought the whole from northern regions. With the most, if not the whole, of these *Champlain Baptists* the drift is supposed to have originated in some way during the prevalence of the water.

We only wish to say that in North-Western Ohio there is not only no evidence of such a submergence, but it is not necessary to suppose it, to account for any of the phenomena of the drift. If the glacier and all its consequences be admitted, nothing further is necessary. Indeed the most indubitable proof of the glacier origin of the drift, and of nearly all of its features, may be read from the drift itself.

VI. No Evidence of the Terrace Epoch.

As there is no evidence of the Champlain Epoch in North-Western Ohio, so there is none of the Terrace Epoch. These two are supposed to complement each other. As the Champlain Epoch waned, the Terrace Epoch advanced. The standing of the ocean at higher levels caused the rivers to run at greater altitude, and to widen their beds. As the ocean receded the river beds were deepened and narrowed, leaving terraced banks. This may be the cause of terraced banks, *where they exist*, but the streams of Central and North-Western Ohio have not terraced banks. In the area covered by the St. Lawrence glacier in North-Western Ohio, the banks of the streams are worn evenly down to the surface of the rock and consist of drift materials only, the water not yet having excavated channels in the rock itself. But in Central Ohio, outside the area covered by the latest period of glaciation, the streams are much older, and have in some cases dug channels in the rock to the depth of thirty or even sixty feet before reaching their present levels. In neither case is there any series of terraces or benches marking so many halting-places in the process of erosion.

4. On the Eastern Limit of Cretaceous Deposits in Iowa. By C. A. White, of Iowa City, Iowa.

At the Chicago Meeting of this Association I had the honor to announce the existence of Cretaceous strata in Guthrie County, Iowa, where they rest unconformably upon the Coal Measures, the locality lying about eighty miles eastward from the Missouri River, and about forty miles west of the city of Des Moines. I have subsequently examined other Cretaceous strata in Brown and Redwood Counties, in South-Western Minnesota, where they rest unconformably upon rocks of Azoic age.

So far as I am aware, these are the most easterly localities in the interior region of North America at which strata of Cretaceous age have been actually observed *in situ*. The Cretaceous rocks first mentioned are referred to the division, which in my Report on the Geology of Iowa, I have named the Nishnabotany sandstone, and the latter, to the division called Inoceramus beds in the same report. All these, as well as all the Cretaceous rocks hitherto known in the interior region, eastward from Eastern Nebraska and Dakota, are referred to the "Earlier Cretaceous" of Meek and Hayden.

I have now to announce discoveries of Cretaceous fossils and fragments of strata containing them, in the drift of Iowa, at other points much further eastward; the collections which have been made at different localities containing specimens which belong to several of the most characteristic types of that period, especially of its later epochs.

During the year 1870 my attention was called to the existence of these fossils in the drift of Howard County, Iowa, by Mr. John T. Smith, of Lime Springs, and a few months ago I visited the locality indicated, in company with him.

It is found in a railroad cut just north-west of the village, which is less than five miles south of the northern boundary of Iowa.

The fossils and fragments of strata are found in the ordinary, compact, bluish clay of the unaltered drift, twenty or twenty-feet beneath the surface of the soil.

The collections have not yet been critically studied, but the following statement of the genera represented in the one made at Lime Springs will give a general idea of its character:—

1. Squaloid teeth, of the genus *Otodus.*
2. Teeth of *Saurocephalus ?*
3. Bones, teeth, and scales of Teliost fishes.
4. *Belemnitella.*
5. *Ammonites* (two species).
6. *Natica ? ?*
7. *Dentalium.*
8. *Ostrea.*
9. *Inoceramus.*
10. *Leda ?*
11. *Cytherea.*
12. *Corbula.*

Mr. P. McIsaac, of Waterloo, Black-Hawk County, Iowa, has lately found a Belemnitella in the unaltered drift near that city in addition to the Ammonite he found there a few years ago. The Belemnitella is of the same species as those found in Howard County, sixty miles directly north. The fish-teeth have been submitted for examination to my friend, Professor O. H. St. John, who writes me as follows concerning them:—

All the squaloid teeth belong to the genus *Otodus* of Agassiz, and may represent three species, but I suspect they are but so many forms of one species; this relationship can be determined only by examination of a much larger suite of specimens, since the teeth vary so much in shape and size, from different portions of the jaws. I have not been able to determine their specific identity, though they are somewhat like *O. appendiculatus*, Ag., a form originally made known from the European Chalk formation, and with which later Cretaceous and Tertiary teeth from this country have been identified — I do not presume to say upon what authority. With *some* of the latter your specimens are intimately related, perhaps identical. You have two or three fragments of teeth (one nearly perfect) which are probably the same, generically, as those from the New Jersey Greensand and *later* deposits, known as *Saurocephalus.*

All these teeth evidently belong to a later epoch than the chalky beds on the Big-Sioux River, near Sioux City, the fishes of which have a much stronger resemblance to those forms of the the Chalk of Europe than have the specimens under consideration, while the squaloid teeth among the latter bear the most intimate resemblance to certain forms of *Otodus* from the Cretaceous rocks of Alabama. Hence I conclude your specimens have been derived from deposits of the Later Cretaceous, probably equivalent to the Alabama fish-bearing Cretaceous strata. That they are *very* late Cretaceous forms there can be no doubt, from the fact of their close relationship to the teeth found in the Eocene of the Old World. I am not prepared to

show how close this relationship is, although the first sight of your little collection strongly suggested their Eocene age.

Although all the specimens forming the subject of this memoir have been found in the drift, they have been found at such localities and under such circumstances as to leave no doubt in the mind of the writer that the Cretaceous sea once extended as far eastward, between the forty-second and forty-fourth parallels of latitude, as the ninety-second degree of longitude west from Greenwich. This is nearly two hundred miles further eastward than any Cretaceous deposits were known, in the interior region of North America at the time I commenced my official examination of the Geology of Iowa, in 1866. What gives additional interest to these discoveries is the fact that the fossils doubtless belong to a Mesozoic Epoch as late as any yet recognized in any part of North America, and much later than that of any Cretaceous strata of Iowa, or of any of the adjacent parts of Nebraska and Dakota, hitherto known. It is true the deposition of *late* Cretaceous deposits only, in the region indicated, requires the assumption that a subsidence took place there during that period, but a similar condition of other strata is found in South-Western Minnesota, where the Inoceramus beds, as before stated, rest upon the Azoic rocks, the older Nishnabotany sandstone being absent there, but present about one hundred and fifty miles to the southwestward.

None of the strata in which these fossils were originally deposited have, as before intimated, been found *in situ;* but fragments of them, and also the material of the drift to which they have evidently in part given origin, show that they were soft and friable like most of the Cretaceous rocks of the great interior region. Consequently they were readily disturbed and removed by the forces in operation during the Glacial Epoch.

While much of the material of these strata was doubtless transported to great distances, and its character as such thus obliterated, delicate fossils, as well as soft and friable fragments of the strata, are found embedded in the gravelly clay so slightly eroded as to forbid the belief that *they* have been transported to any considerable distance from the place of their origin. The fragments of strata referred to have been recognized, so far, only at Lime Springs, but their presence there, as well as the condition in which they are found, inspires the confident hope that we may yet find some of these Cretaceous strata *in situ* in that vicinity.

These discoveries also suggest that we should scan more closely than ever before, not only the character and contents of the drift of Central and Eastern Iowa, but also some of the *strata* of the same regions, especially the sandstones, to determine with certainty whether some of them may not be of Mesozoic age.

On page 98, volume I. of my Report on the Geology of Iowa, I have the following remarks, which in some degree anticipated the discoveries announced in this memoir:—

Mr. P. McIsaac, of Waterloo, Iowa, has shown me a specimen of Cretaceous Ammonite which he found in the drift near that place, and a fragment of a Baculite has been found in the drift near Iowa City. Some shark's teeth have been found in the drift of South-Eastern Iowa, and supposed by others to have originated in a northern prolongation of the Gulf-border Tertiary formations, but it seems not improbable that they originated in Cretaceous strata to the north-westward, and were transported thither during the Glacial Epoch; although it is not to be denied that they approach more nearly to Tertiary, than to Cretaceous forms.

The shark's teeth here mentioned were supposed to have been transported thither from some locality in North-Western Iowa or South-Western Minnesota, where Cretaceous strata were known to exist, because it was not then supposed that any strata of that age ever existed further eastward, in the interior region, than the ninety-fourth degree of longitude, and it was thought probable that the southerly-moving drift-currents might have been sufficiently deflected to the eastward to carry them there. From the slight opportunity I have had to examine the teeth here referred to, I am led to regard them as of the same species as some of those found at Lime Springs.

From the last named locality to the south-eastern corner of Iowa the direction is so nearly south, we cannot doubt that the teeth found at the latter point may have been carried thither from the former, by a drift-current; but the most easterly known Cretaceous strata of South-Western Minnesota are too much to the westward of Lime Springs to allow us to suppose, even in the absence of corroborative proof to the contrary, that the Cretaceous fossils of that locality may have originated at a point so far westward, because all the facts hitherto observed show that the general direction of the drift-currents which passed over this part of the great interior region did not vary much from south.

It is probable that that the Cretaceous fossils found in the drift of Black-Hawk County may have originated near where they are

found, but that county being directly south of Howard, they may have been carried thither from that more northern region by a drift-current.

Should it be denied that the Cretaceous fossils and fragments of strata found in Howard County are from strata originally deposited in that vicinity, the only alternative would be to assume that they have been carried thither by drift-currents. Following, is a condensed statement of the facts supporting the former proposition and opposing the latter: —

1. All known Cretaceous strata of the interior region north of the latitude of Howard County are too directly and too far to the westward to allow us to suppose that any drift current could have traversed lines having a direction so much to the eastward.

2.* Those Cretaceous strata are not known to contain any of the species found in Howard County.

3. No boulders of the Sioux quartzite have yet been detected in the drift of Howard County, although it is found *in situ* over a large part of South-Western Minnesota. That region is also, in part, occupied by the Cretaceous strata just referred to. If south-easterly moving drift-currents had existed there, they would have carried material from both these kinds of rocks to Howard County as they *were* carried into all Western Iowa by southerly moving currents.

4. In the drift, accompanying the fossils of Lime Springs, are found fragments of the palæozoic rocks which occupy only the region to the north and east of that locality, showing that they must have been brought there by either southerly or south-westerly moving drift-currents. Therefore the Cretaceous material accompanying them must also have been brought by the same currents, if by any. If they were brought by these currents (which is not likely), that alone would establish the fact of the great eastward extension of the Cretaceous sea, which it is the object of this memoir to prove.

5. Many of the Lime Springs' fossils are delicate, but they are

* Since this article was read before the Association, I have received from Mr. J. C. C. Hoskins, of Sioux City, a quantity of fossils from the Cretaceous strata in that vicinity and further north. Among these are teeth belonging to the genera *Ptychodus* and *Otodus*, the latter very closely related to those of that genus found at Lime Springs, but probably specifically different. In any case these specimens of *Otodus* thus associated show the existence of forms, in "Earlier Cretaceous" strata, that were hitherto supposed to have their earliest imit in the latest strata of Cretaceous, or the earliest of Tertiary, age.

not broken nor eroded, and fragments of the soft and friable strata containing them are not comminuted, while the accompanying fragments of palæozoic strata are all hard, and show evidence of such attrition as would have comminuted the softer material, if it had been subjected to the same forces.

6. The immense energy of the drift forces and the softness of the material of the Cretaceous strata believed to have been deposited in the region of Howard County, seem to be sufficient to account for their almost entire obliteration; while they were still further obscured by the great accumulation of drift material which prevails in that region.

II. ZOÖLOGY AND BOTANY.

1. On the Relation between Organic Vigor and Sex. By Henry Hartshorne, of Philadelphia, Penn.

The observations of Thomas Meehan upon the relations of sex in plants, published in the "Transactions of the American Association for Advancement of Science," and elsewhere, are entitled to the attentive consideration not only of botanists but also of students of general biology. In his papers of 1868, 1869, and later, Mr. Meehan has endeavored to show that "it is the highest types of vitality only which take on the female form."* His facts have referred mainly to *Coniferæ* and *Amentaceæ*, although not confined to them.

The hesitation felt by many minds in regard to the acceptance of the above proposition has originated chiefly from the familiarity of the principle that "there is a certain degree of antagonism between the nutritive and the generative functions, the one being executed at the expense of the other;" along with the weight of some very familiar facts concerning the generally greater size

* Proc. of Amer. Assoc. for Advanc. Science, 1869, p. 260.

and muscular strength of the male among animals (with a few exceptions, as in certain raptorial birds and arachnida) as well as the equally general superiority of male birds in voice and plumage.

Some of the facts in regard to plants cited in the papers referred to may *possibly* bear a different, even an opposite, interpretation to that given by Mr. Meehan. In his example of the larch, for instance, when we notice that after surviving several years of the repeated production of female flowers, the branches or spurs "bear male flowers and die," * is it not possible that the demand for organic force required in the evolution of male flowers *causes* their exhaustion? In another place † Mr. Meehan speaks of "the loss of power to branch," which in the Scotch pine, "the formation of male flowers induces." This view might comport, at least, with the ordinary statements of physiologists, as represented by Dr. Carpenter ‡ who refers to the contrast between Algæ, in which individual construction is especially active, while the fructifying organs are obscure, and fungi, in which almost the whole plant seems made up of reproductive organs, upon the maturing of which the plant ceases to exist. This contrast between nutrition and reproduction appears again in the larval and perfect stages of insect life; the one being devoted to nutrition and the other to reproduction. Is there any doubt that, in the dahlia and other Compositæ, *cultivation* alters *fertile* florets of the disk into *barren* florets of the ray? The gardener's common use of the principle of *limiting nutrition for the increase of reproduction* is alluded to by Mr. Meehan in his paper of 1870, § in speaking of a branch being "partially *ringed to produce fruitfulness.*"

But my purpose in the present paper is especially to call attention to a few well-known facts in the animal kingdom, of a character somewhat analogous to those dwelt upon above concerning plants; which conspire with these, in suggesting that some qualification or addition may be required to the ordinary statements concerning the relations between nutrition and reproduction, or at least as to those between organic vigor and sex.

Take the instance of the common hive-bee (*Apis mellifica*). According to the observations of Dzierzon, Von Siebold, Leuck-

* Proc. of Amer. Assoc. for Advanc. Science, 1869, p. 257.

† Proc. Acad. Nat. Sciences, Phila., 1869, No. 2, p. 122.

‡ Principles of Comparative Physiology, p. 147.

§ Proc. of Amer. Assoc. for Advanc. Science.

art, and Tegetmeier upon hive-bees, and of F. W. Putnam, J. Wyman, and Gerstæcker upon humble-bees, it appears that there is a regular gradation in rank, so to speak, of bee offspring, according to the method of their production. First and lowest in the hive-bee series are the males or drones. These may be sometimes produced by an unfertilized working bee; commonly, by a queen bee from ova not fertilized with sperm-cells, which cells, as observation and experiment both have shown, may be for a long time detained in the spermotheca charged with them. A queen whose fecundation has been delayed till she is older than usual, is apt to yield only drone offspring. The next stage in rank is that of the worker, or undeveloped female. Every one knows the remarkable effect of nutrition upon its characters; a change of cell and food elevating it to the full endowments of a queen. Putnam and Gerstæcker* have noticed among humble-bees what are called "large queen larvæ," intermediate between the workers and the perfect queens; and Wyman has suggested that the earlier or later period of impregnation may determine this difference; those first impregnated becoming queens, then the large queen larvæ, next the workers, *last the males.*

Now among the Aphides as well as to a certain extent in some Molluscoida, Cœlenterata, &c., we find a class of facts, different from these but yet allied to them. Taking Huxley's summary of the history of aphidian parthenogenesis,† it seems that the number of successive viviparous *pseudovan* broods is "controlled by temperature and the supply of food. The *agamic* viviparous individuals are regarded by Steenstrup and others as *non-sexual.* If sexual, they must be considered as females undeveloped. At all events, the coming on of cold weather begins the production of males as well as females. Packard's expression is that "the asexual Aphis and the perfect female may be called dimorphic forms." Of the three forms, then, that one whose production especially attends the conditions of the lowest vitality is the *male.*

But another class of facts of a quite different kind may be considered in this connection; involving higher animals and even man himself. I refer to the history of monstrosities. Double monsters (of which some remarkable human instances have been exhibited

* Packard's "Guide to the Study of Insects," p. 119.

† Linnæan Transactions, xxii., p. 198.

within a few years in this country) are always of one sex and *nearly always of the female sex.** There is reason to exclude from this class of true double monsters cases like that of the Siamese Chang and Eng, who may be regarded as really twins with two complete bodies abnormally united together.

Now, why should a double fœtus nearly always have the female sex? The bearing of this question upon that which we have just been discussing appears, when we consider the true theory of double monsters. Under the close investigations of St. Hilaire, Virchow, Vrolik, Fisher, and others,† it has been made quite evident that they result not at all from the fusion of two embryos into one, but, on the contrary, from the abnormal *fission of a single ovum*, under *excess of formative force.* The point for us now to notice is the nearly constant association of this profusion of developmental force with femininity of sex.

Regarding the actual function of this force (however we may designate it, as, *e.g.*, life force, organic force, bio-plastic force, &c.) as being the formation of plasma with attendant cell-multiplication or *vegetative repetition*, it would appear that *this* is precisely what, in plants and animals, may be the especial feminine endowment. The two directions or modes of manifestation of this organic force are individual construction and reproduction. These may, therefore, be in inverse proportion to each other, simply because the energy or material consumed in the one process is taken from the other; and yet, while a *certain* limitation of food and temperature favors reproduction, rather than individual nutrition and construction, a *greater* lowering of these conditions of vitality will retard, arrest, or degrade both processes. According to Meehan's interpretation of his facts concerning plants, one effect of this lowering, retardation, or degradation is the production of the male rather than the female sex. Some facts, at least, in the animal kingdom, as we have seen, support the same view; but to give a statement of this kind the form and validity of a law would require a much more extensive survey of correlated facts. At all events, we do not find the frequent superiority of the masculine sex in certain particulars in the higher animals necessarily incompatible with

* G. J. Fisher, Trans. Med. Soc. of New York, 1865–1868. Against this I find only a vague expression of W. Vrolik (Cyclop. of Anat. and Physiol., Art. *Teratology*, p. 946) that "some sorts" of double monsters are more frequently male.

† Goodell, Philada. Med. Times, June 15, 1871.

this; since this superiority prevails usually in apparatus not of the functions of the *vegetative* or organic life, but of *animal* life or of relation; as of *intellection*, *motor* power, and *voice*. Beauty of plumage in birds, while we naturally attribute to it a certain superiority, may not, in the scientific sense, unequivocally have this character. If it should be conceded that it has, we must then regard its general predominance in males as one of the difficulties in the way, at present, of any extended or final generalization upon the subject.

Another possible application of the same course of reasoning is, in regard to the law of increase of human population. Extended observation has shown a constant preponderance of male over female births. In Europe, according to reliable authority,* the average proportion is, 106 males to 100 females. But, this difference of sex is less by three per cent in illegitimate births; that is, in the latter, where vital energy may be supposed to abound above the average (sexual propensity over-riding prudence and morals, and thus attesting its own strength) there are three per cent more than the average number of females born.† More to the purpose, perhaps, may be the fact that, of children *still-born* there are, the world over, about 100 males to 75 females; and, further, that the mortality in male children during the first part of life considerably exceeds that of females. Under one month of age, for example, in England, 1000 males die for 765 females; in Belgium, the proportion is 1000 to 749.‡ During the first year of life, in Kentucky, Dr. Sutton has ascertained § that of every 100 dying, 57 are males and 43 female. This excess of male mortality continues until puberty, and returns again after the dangers peculiar to female life are passed; so that after sixty years the probability of long life is greater with women than with men. There are more very old women than there are very aged men. It is at least allowable to interpret these facts as being favorable to the idea of greater viability, *i.e.*, purely vital or organic energy, belonging to the female sex.

Less directly connected with the same view are some other facts concerning population which have a practical interest. Statistics

* Wynne, Vital Statistics, p. 76.

† The relative *mortality* of illegitimate children is determined by causes acting at or near the time of birth, long after the fixation of sex.

‡ British and Foreign Medico-Chirurgical Review, April, 1857, p. 348.

§ Wynne, Vital Statistics, p. 126.

of some parts of the United States have been, especially by the inquiries of Dr. Nathan Allen, of Lowell,* shown to indicate diminution in the prolificacy of American women, as compared with foreign immigrants. Examining, *e.g.*, the records of New York City for 1870, we find that, while the number of *deaths* of *natives* is nearly double that of foreigners, the number of *births* of children both of whose parents are *foreign* is almost *four to one* of those whose parents are both native. For so great a difference there must be a cause. Dr. Allen ascribes it to a deviation from the normal harmony of development of all the organs and functions, owing to unsanitory modes of living amongst women, as well as men, in this country. That the general physiological balance which constitutes standard health is on the whole most favorable to continued and vigorous reproduction, is probable; yet the special kind of disturbance of balance which tends to interfere with productiveness, needs to be pointed out. Is it not probable, in view of the facts alluded to in this paper, that it involves an excessive increase of activity in those functions farthest removed from the nutritive, — which are most of all animal as contrasted with the vegetative, are indeed at the opposite pole as it were, from the latter. These are the functions of the brain and nervous system. Precocity, in the intellectual and emotional nature, is common in both sexes in this country; over-intensity, activity, and excitement of mind, in business, dissipation, and even in religion, are characteristically American. Thus it would seem that the vital organic energy is impaired; and one important manifestation of this may be the lessened and lessening productiveness of American women. It cannot yet be said, however, that the facts upon this subject are so definite as to allow us to deduce an unquestionable conclusion.

* Transactions of American Medical Association, 1870, p. 381.

2. Mortality of Fish in Racine River. By P. H. Hoy, of Racine, Wisconsin.

During the summer and autumn of 1871, the minnows, *Alburnus rubellus*, Agassiz, became so numerous that, in calm weather, at which time these little fish swim near the surface, they could be seen in such immense shoals that they produced a spattering in the water closely resembling a shower of rain falling. As the dense mass moved along, if opposed by a stick, or other slight obstacle, the fish nearest the surface would leap over the object, it being almost impossible for them to go under in consequence of the solid mass of fish moving beneath.

Other fish, bass, pickerel, suckers, catfish, &c., were also numerous; most of these larger fish subsisted, almost entirely, on the little delicate and tender minnows.

On the first of December, the river, being unusually low, froze over; the ice thus early formed became twelve inches in thickness by Christmas. A slight rise in the river occurring about this time filled every crevice underneath the ice, and this water freezing closed up all air chambers. Immediately it was observed that the fish crowded to any opening made in the ice. So eagerly did the minnows crowd, in great distress apparently for want of oxygen, that they literally shoved numbers out of the water upon the surrounding ice. Death soon followed. The great number that thus perished rendered the water of the river horribly offensive.

By the middle of January all other fish, bass, perch, &c., below the rapids also died; caused, probably, by the poison communicated to the water by the multitude of decaying minnows. A fact going to prove this position is, that there are none of this species of Alburnus found above the rapids, the river being at this point obstructed by a series of dams; and here, too, where the *minnows* do not occur, other species of fish continued in good health, there being no unusual mortality.

From the middle of January the water in the river, below the rapids, became so horridly *stinking* that those manufactories situated along the river were compelled to use agents, — tar, carbolic acid, chlorides, &c., — either to decompose or cover up the stench caused by generating steam from this *liquid mass of putrefaction.*

When the ice broke up in the spring, thousands of barrels of fish were swept out into the lake, and great masses heaped up on the beach, near the mouth of the harbor, by the waves.

I examined many specimens of these dead fish, but could detect no evidence of disease. They appeared in good condition; the minnows were especially fat.

Perhaps the most interesting fact in connection with this fish mortality is, that many minnows sunk, and there became covered with the soft river mud, where, in the short space of six months, they became *semipetrified*. The change closely resembled, if it was not, *adipocerine*. These fish, however, became lighter than water, so that they rose and floated off; while the flesh of *mammals* increases in weight by being converted into adipocerine. May it not be that *fish* undergoing the change differ essentially from mammals? *

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3. THE OLD HAARLEM AND THE LATEST BRUSSELS MICROSCOPICAL PRIZE-QUESTIONS. By THEODORE C. HILGARD, of St. Louis, Missouri.

THE microscopic facts recorded in the opening of this paper form part of a communication read before the New Orleans Academy of Science, and partially published in the scientific column of "The New Orleans Picayune," February 11, 1872.

The second part, concerning prize-questions, has a direct bearing upon subjects and results as yet unknown in Europe, but exhaustively experimented upon and published in the scientific press of America. Of *three* original constituent papers (discussed at the Chicago Meeting in 1868) of my tripartite Essay on "Microscopic Circuits of Generation, Infusorial, Zymotic, and Bryogenetic," the first part was published in the "American Journal of Arts and Sciences," and reprinted in the "Journal of the London

* Specimens were exhibited, and distributed to eminent chemists for analysis.

Microscopical Society." The two others were published in the "Proceedings of the American Association for the Advancement of Science," 1870 and 1871.

The first appearance of organisms in any fermenting liquid is that of the *naked saltatory* molecules, called (or at least subsumed as) Monads (*pseudo*-genus) by Ehrenberg, and *vibrios, or vibrionic molecules* by myself.

They compose the yeast-diastase of Liebig, and their chemical constitution is that of *flesh.*

Any small particle of fungous dust, a fragment of a fungous fibril, especially of the common lacteal, bread and apple-mould (which likewise is the ferment of all putrid corruption), will *bodily dissolve* into a *vibrionic, molecular gelatine,* of blackish color, when alighted in or on fermentible material. No fungus has a cellulose or *papery* fibre, coat, or cell. Searching for "cellulose" in a mass of yeast-cells argues a thorough misunderstanding. The adult fermentic fungus, moulding and corrupting our bread and flesh, consists of cells, but not of "cellulose," and so does the fermentive "yeast-cell" likewise. It is a grave and fatal mistake to ascribe fermentation of starch into sugar, and of sugar into either alcohol or lactic acid, &c., to the (*coated*) yeast-*cells.* Whenever sugar, &c., has to be converted, the yeast-cell at once dissolves its coat into a nutritious gelatine, prolapsing its vibrionic (commutative or truly *fermentive*) molecules, as will appear on making the check or test experiment.

The primitive yeast, likewise, consists of a *nebula* of growing, vibratile molecules.

Liebig denied the yeast to be present in putrid cadaverous corruption, because his microscopist saw no *cells,* and he himself saw no cellulose membranes, which, by the way, the yeast itself never possesses. The well-known extracellular, as well as intracellular vibrionic particles, or diastase, Pasteur's school claimed for animals, — "snakes, snapping up vibrios." What species of serpents those were, truly "more subtle than any animal made" (adult animal), is left in the dark. The vibratile tail, or *scourge* of all primitive life-molecules, might indeed be claimed as the very "finest of all serpents" yet; *finer than any true animal whatever.* As it is, it forms an active instrument of flagellation upon convertible, digestible, or fermentible liquids.

Without these *spermoid serpentine particles*, no living tissue can be formed.

A single vibrio will sometimes directly enlarge and assume a cell coat as an individual yeast-cell; but, in most cases, during the process of actual cadaverous corruption, no less than during the true fermentic process of converting sugar, &c., into alcohol, or lactic acid (accompanied by the evolution of carbonic acid), *no cell whatever need be formed.* I have repeatedly fermented grape juice, and simple corn meal with water, not allowing, however, of any *drying up* at the borders of the vials. In all these cases the lactic as well as alcoholic, and the fearfully miasmatic, putrid fermentation, as of flesh or moss spawns (which is likewise a *gangrenous* one), no less than the offensive butyric acid, &c., corruption (as of mashes, swill, distilleries, levees, and the cane refuse), all were enacted without the presence or formation of the ultimate cells of the yeast, that only *hoard up the fungous material on hand*, and *redissolve* in fermentible liquids.

The process of the *vibrionic concatenation* (or, *inosculation in single file*, of the primitive fermentic molecules) has been partly observed by Pasteur, as well as Hallier. Ehrenberg described this (corruptive) yeast molecule not inaptly as "monas crepusculum,"— a "hazy, nebulous monad," a carnivorous (!) animal, inhabiting, as he gives it, chiefly "St. Petersburg, Berlin, and other European capitals."

The naked "monads" or vibrios which lengthwise joined in single-file — a process unknown to him — he describes as "ophidomonas" (or snake-monad), as it is found violently revolving, like an archimedean screw. These are Pasteur's serpents; snapping up vibrios. They inosculate by pairs after much spinning or *churning*, so to speak, and then join other longer or shorter files, or parts of weltering coils, adding to their length. This well-known process has once more been misconstrued, by Cohn, into a "transverse division."

So soon as a few vibrios or primitive flagellate molecules become united, the vibratory *halo* which surrounds each one singly at once disappears, except at the ends, which are actively twirling the little frustule, curve, or coil around, and are seen delving against any slimy material they may meet in their way. It is thus that they become entangled, involved, or enveloped in any gelatine, or in spoiled meat (immersed through a bung-hole), and in which they stick fast and are easily got rid of by extracting them with the meat.

After a little while, when apt to encyst, they "become still," *e.g.*, adhering to the glass slips between which they were bred, by way of experiment. They then are seen to become a little dilated, or, as it were, *dropsical, exude a delicate cell-membrane, and now represent a little fibre.* In fermentible liquids, the worm-like, dropsical fibrils rapidly segment and ramify off into beads; *thus constituting the yeast-cells.* The latter again multiply and elongate into moulds, fibrils, and floritions. In stagnating or impure flowing water, these slim fibres, of about 1-40,000 of a line in thickness, collect into the prancing, fluctuating, dirty tassels observed in the street gutters of cities, &c., and, although themselves inodorous, they exhale the rank gangrenous, or the infectious butyric, miasmas which at once seem to affect the fermentible contents of the blood and liver more especially.

With respect to the latter action upon our system (easily realized by breeding those effluvia in a little corked bottle), we need nowise assume a specific parasite; but merely an *altered* action of our *own*, "*specific*" *organization!* As for the propagative action of certain effluvia, we have a similar function in the action of fire, *kindling organic substances.* In organic bodies, an action once started will oftentimes be apt to run like a wild-fire until it ceases to find nourishment. But there are other "kindling" substances than fire — *i.e.*, heat and oxygen — alone. Nitro-glycerine, an organic compound, will explode at the touch of resinous substances. The *communication* of the action is all that is required. Our whole system itself being a regenerative as well as self-decomposing or excretory one, its "regenerative action" might be directed perversely; or the equivalents, hoarded up, be fired by a "specific fire."

Fire, indeed has ever been a symbol of contagion. "*Kindling*" conveys to the present day the idea of contagion in the German language. Inorganic bodies are ultimately, in their last particles, uniform, or *compact*, so to speak. Their uniform reaction upon physical agents constitutes the "chemical property." Uniform reaction, uniform being, is called *dynamostatic* condition, properly so as compared with the aëriform, or *pneumostatic*, reaction of matter; the liquid or *hydro-static* and the *static action* of inertia, as in solids, to *persist in the sense of the force communicated* (in a straight line). *Static persistence* is the character of inert matter, persisting as such into unlimited time and space ("*stat*" *terra in æternum*). Inorganic matter will only burn, if sufficient heat, or

other work done or bestowed, *e.g.*, by pulverizing or refining it into separate particles, be *superadded.* Thus sulphur, *e.g.*, will not burn, except by *adding* all the equivalent heat, or so much work of pulverization (as in the manufacture of sulphuric acid the sulphur is burned by setting a pulverized portion on fire). Sulphur will burn copper in a ruby-red flame, when rasped down and heated; but neither they nor phosphorus, either, will, in a low temperature, *kindle.* This "kindling," or *spontaneous continuation of the process of oxydizing carbon, in burning, is exclusively the property of organic matter;* and it is, moreover, the *fundamental common feature of all plants, as well as animals, to render up carbonic acid gas.*

The specific heat of all animal bodies is due, as is well known, to their process of respiration, whether by lungs, gills, or insects' tracheæ. All absorb oxygen and render up carbonic acid gas by a peculiar process of a low combustion: due to the slow, propagative firing of carbon stored in their tissues. (It is hence predicable, in the strictest, literal sense of the word, that their *breath slowly ignites, or "kindles charcoal."*)

It was solely on the basis of an absolute and quite an unpardonable sin of omission, viz., *neglect of the normal* or of the *check experiment*, that of late half a hundred of pretended "specific" fungi have been claimed as "parasites, producing so many specific diseases." Let it at once be stated as a historic fact that the normal process of fungous *decay* (or corruption) of stools and offals, as of flesh and blood, had *hitherto never been studied.* In adopting, publishing, and still worse, enforcing by legal enactments the recognition of certain supposed characteristic or "specific" fungi, no one ever asked or dared inquire what is the *inevitable normal corruption of the flesh.* This condemns the whole system at once, and even the late *dementi* given to such foregone assumptions, *e.g.*, about a so-called "cholera fungus," which is normally evolved upon all healthy discharges no less than on diseased or morbid ones, actually came *too late.* That check ought to have been *required* before sending a committee to hunt for it to the jungles of India, who found no distinctive fungus at all. But that *that* fungus is only the common *fermentive yeast or mould of our larder*, no one could say but who had examined it in its continuous development, by growing it reversely and conversely, under the microscope. To call these semi-liquid, naked, sarcode bead-strings a "saccharomyces," after so many

names (from Ehrenberg forward) had been given, appears as a mere redundancy of diction, if not as a want of deference due to eminent priorities; particularly if once more a new specific name is given, as a so-called species and genus, that, however, *had never yet been traced*, and thus far *required to be demonstrated*, as all assertions of peculiar features, claimed, require to be brought to this "crucial" test of *contradistinctive experimental comparison*, before they can claim deserving any publicity whatsoever. The fundamental rule, to first establish the *normal* feature before a "distinctive" character can be allowed, is constantly neglected.

This, however, is by no means intended as derogatory of well-authenticated scientific experience concerning parasitic diseases — of whatever nature — both on plants and animals.

As for modern researches concerning putrefaction, we must be careful *on what evidence the statements are based*. I extract the following statement of Cohn — a much-quoted observer — on the Characters of Bacteria, as represented in the "Scientific Record" of one of our leading monthlies for August, 1872. He states:— 1. "Bacteria are cells." Such, indeed, has always been the distinctive feature of *bacteria*, against *naked molecules*, to be possessed of a *cell-coat*. 3. "Bacteria-cells multiply by transverse division." This holds good, *e.g.*, of the terminal (*true*) *bacteria* of the matted (mother-of-vinegar) vibrio-files, that form the white scums, or *vappa;* and also for some of the multifarious, retrograde bacterial developments *from submerged penicillium and oidium-joints of the Yeast-Fungus*, as depicted in Fig. 11 of Plate, and p. 298 in "Proceedings," 1870; phenomena most easily realized by *breeding or examining the respective phases, under the microscope*. 6. "The bacteria are the only organisms which produce putrefaction." This involves one of the gravest *errors of diagnoses*. The single or concatenated "monads" or *vibrios* enacting (or, at least, mostly exclusively present at) the work of putrefaction are essentially *naked;* but surrounded by a *whirring halo*. The apparent optic rim (— *not a cell-coat!* —) *disappears*, except at the terminal ones, so soon as they are duly *adapted into file by concatenation* (*not*, *by division*). Coatless molecules are not classed as "bacteria."

7. "They heap up into palmella-like masses (zoōgloea)." This involves no less than *four* diagnostic *quid-pro-quos*.

(*a*) It is the vibrionic chains, which curdle up, *e.g.*, into the glutinous mother-of-vinegar. (*b*) *His* zoōgloea is the same as Klob's, viz., an endogenetic discharge from oidium-joints, — Fig.

11, "Zymotic Fungi." (c) The original *true* "*Zoögloea*" *Dujard.* are the trabecular embryonic pellets of the oxytricha-phase of Vorticello-Planarian grubs (see "American Journal of Arts and Sciences," vol. ii., August, 1871; and "Zymotic Fungus," p. 298). (e) Furthermore, Palmellaceæ, so-called, are a form of moss-spawns or Chlorospermeæ Harv.; of a *chlorophylline nature and of green color*. Besides all this, —

"He thinks he has abundant evidence to prove that *bacteria* and *penicillium* are independent of each other, and that the former cannot [*sic*] be produced from the latter."

The various modes which Nature *evidences* in her operations can be inferred from Plate of "Zymotic Fungus," Fig. 11, and text, p. 298.

From the "Scientific Record" of the same widely circulated monthly ("Harper's") we copy the following paragraph, in as evident and direct connection with Mr. Cohn's difficulties or failures, as was the old prize-question of the Holland Society, Amsterdam (see end), concerning Kuetzing's more instructive work on chlorospermous spawns: —

"As a memorial of its deceased member, Mr. Antoine Joseph Spring, an eminent Belgian botanist, who died at Liege on the 17th of January, at the age of fifty-seven, the Academy of Sciences of Belgium has added the following to the prize-questions of 1874: The polymorphism of the mushrooms is attracting more and more the attention of botanists and physiologists, and seems suited to furnish new elements for the solution of the problem of life in general. First, a succinct and critical summary of the known observations of the polymorphism of the Mucedinæ is demanded; second, an exact determination, even if based upon a single species, of what relates, first, to the proper nature of the plant (its specific energy), and second, to the exterior (the conditions of its development); third, the positive proof or disproval of the fact that the fungi of ferments, such as micrococcus, palmella, mycodermi, &c., under any circumstances, can be transformed into the higher fungi."

Ad 3. (*a*) Palmella is a *chlorospermous* (*pseudo-*)*genus;* and as such it could never have truly entered into competition. (*b*) If a "mycoderm can be transformed into the higher fungi," then that mycoderm belonged to — and was *itself* — the fungus in question, not a "higher" one any more than the hen is a "higher" *bird* than the egg! The lucky Œdipus would here be caught by this Sphinx in a glaring *contradictio in adjecto*, and *eo ipso lose his claim* on his laurels!

Ad 2. No plant can exist without external conditions. The

"specific energy" is utterly inseparable from "conditions of development," and therefore cannot be separately treated.

Ad 1. For sufficient proof in point of *observed developments and organalogy* (rather than the merely diagnostic "polymorphism"), it is needless to refer our readers to my previous communications on the very Yeast-Fungus (or Mucedineæ series itself). A *self-sustaining* series of observations is always more reliable than any series of *failures*, — of diagnostic slips and "negative" evidence!

A most instructive case of similar nature is involved in the following, originally forming an appendix to my last year's publication on "The Fresh Water Algæ as the Spawns of Mosses." As a just tribute to authors who can claim certain priorities, I now offer it for the consideration of the rational microscopic investigator.

Valuable observations, indeed, had partially been made, and certain important results no doubt been arrived at, *e.g.*, by Professor G. Kuetzing; and Professor W. P. Schimper's excellent monograph on Moss-Developments ("Récherches sur les Mousses," Strasbourg, 1848) has been mentioned before. A great many of the developments, above described, had been *independently discovered by Kuetzing;* but his prize essay fell almost still-born from the press, partly on account of an entangling alliance between *subjective, fictitious* identities, of merely diagnostic framing (such as, *e.g.*, of *pseudo-*"genus Protococcus") on the one, and *Nature's identities* (of *objective merit*) on the other hand; partly, however, on account of the barbarous Greek terminology — of the Composite style — which even at the present age more than any thing else obstructs the way to a clear *understanding* of what is to be gained by it.

A very fair idea of the multifarious collateral developments, incident to certain spawns of Lichens and of Mosses, can indeed be gleaned, even from a single plate, *e.g.*, Table *Q*, of his crowned prize-essay: "Die Umwandlung niederer Algenformen," &c. (in "Natuurkundige Verhandelingen," &c., Haarlem, 1841). The works of Kuetzing, Schimper, and Harvey, having remained inaccessible to me before I had myself finished my researches on such subjects, the amount of corroborative evidence herein conveyed forms so many self-sustaining, *independent equations*, mathematically speaking.

A most interesting *error of question* (by foregone diagnostic

assertion) will be readily detected in the wording of the original prize-question itself, as couched by the Holland Society, Amsterdam. To wit: —

"According to some botanists, algæ [?] of a very simple structure are averred to develop, under favorable circumstances, into very different plants [!] which belong to genera much higher elevated in the scale of organic beings [!]; whereas the same algæ in default of such favorable conditions were fertilized* and reproduced in their original form. The Society considers, that if these observations could be rendered unimpeachable, and if the transition of two organic bodies [*sic*] into one another could be proven to a certainty, an immense progress would have been achieved in the study of such bodies," &c.

Did the Society actually mean to ignore the conversion of the *organic body of the egg into that of the hen?* — of the calf into the heifer and cow — nay, of the body of the ham into that of Prince Hamlet (if need should be), *even by way of assimilation?* Does not the bulb reproduce the original form as well as the seed? Could the adult be called a "higher genus"? Was not the value of such "genus," "scale," or "body," an *implicit error of question* in each single case?

Starting from a foregone conclusion, by assuming the essential identity of any green cell lying loose (as a postulated "genus Protococcus"), Kuetzing unfortunately infers the genetic unity of all the rest, because he was unable in each case to account for its *distinctive origin* (or "nature," proper). But things are not to be held identical, simply because our means of discrimination fail us as in all very small or very distant objects.

He therefore "very simply" claims a *generation without a generation* — euphemistically called "originarian!" — for his ideal punctiform Protococcus, the advent of which he could not trace "because *no seed could be small enough* to produce such forms;" — a foregone tenet, based on habitual ideas of seed and semen.

Without detracting from the merit of the objective observations (faulty though the subjective logic was), we here literally transcribe from p. 29, § 33 of his crowned Essay, a summary of results gained: —

"§ 33. So far as color, size, and external cell-substance are concerned, the synaptic phase passes through the same tertiary grades as the endogon-

* The true distinctive feature, involved, was the seemingly (*i.e.*, preconceived) "sexual" or "*bi-*"sexual *transfusion of contents*: a process of *tissue-genesis*.

imic and gonimic secondary grades. Here, too, we therefore distinguish the microsynaptic and macrosynaptic, the achromatic-synaptic and chromatic-synaptic, the myxodermatinic-, pachydermatinic-, and leptodermatinic-synaptic."

We recommend this as a study, and our classifying co-temporaries *may profit by his example!*

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4. A Critical Review of the Present System of Osteology. With Particular Reference to Professor T. H. Huxley's Latest Views. By Theodore C. Hilgard, of St. Louis, Missouri.

In his lately published "Manual of the Anatomy of Vertebrated Animals," Professor T. H. Huxley complains of the inefficiency of the present system of accepted "homologies" respecting the extremities in different classes, &c.

On page 37 he states:—

> The pelvis possesses no osseous element corresponding with the clavicle; but a strong ligament, the so-called Poupart's ligament, stretches from the ileum to the pubis in many Vertebrata and takes its place.

This might be claimed as the *climax* of a failure to adapt the present conventional system to the minutiæ of detail.

All comparative osteologists present at the last Meeting, at Indianapolis, even those from across the ocean, have competed in denouncing the present system of so-called homologies, as leading to impossible or incompatible consequences.

That actual homologies exist to an hitherto unknown degree, if, *legitimately, i.e., consistently, traced by immediate connections of transitional forms;* that in the entire Vertebrate System *all bones can be coördinately and respectively located,* by incontrovertible, connected evidence, I have already demonstrated in my

last year's paper "On the Numeric Relations of the Vertebrate System." *

Wherever we have a uniform law of type, there we are apt to confound homologies — or *identical organs* — with analogies or *partial identity of features only.*

It is only by a method of strictly continuous discriminative comparison that we can distinguish between total identities or homologies and the various special features only partially held in common.

The chief deficiencies of the present system, as *embodied in its technical language*, can be briefly specified as follows: —

1. Neglect of *Embryological Considerations:* with respect to (*a*) *sternal* organization, (*b*) *occipital* development, (*c*) embryological composition of neural as well as hæmal *rib-arches, of the cranium* in particular; also with regard to (*d*) typical correlation of *extremital fabrics inter se*, (*e*) of ribs *inter se*, (*f*) of *gill*-arches as "hæmal" arches; distinct from (*g*) "*visceral*" arches or facial, carniferous lobes of embryology.

2. *Failing to proceed from indubitable connections*, coexisting parts have not been accounted for completely, distinctively, and comparatively. Analogous parts have been misinterpreted for

* The proof-sheets of that paper not having reached me in time, it has happened that, apart from other inconsiderable *errata*, the following seem to require emendation: —

Page 808, last line, read, arch-beams (for "arches").
„ 809, first line, read, that being *cemented*, &c.
§ 3, line 3, observed, among fungi, &c. § 5, line 3, pollinary gland(&c.).
„ 811, § 2, line 2, *not* the "hæmal," &c. Line 5, fauces — the tymp., &c. Line 6, lachrymal ones (*choanæ*), [not *cloacal*]. § 3, line 2, *hiatus* of the neur., &c. § 4, line 1, *intracted*, or *incurrent*, &c.
„ 812, line 4, appressed [not oppressed]. § 2, line 4, In the cat-fish, they [not: cat, first it] resemble the carapace of a turtle. Line 9, joining the neural spine, as in the turtle.
„ 813, line 2, In birds, the strong, pillar-shaped *prop of the shoulder-blade is the true clavicle.* Line 8, (ribs). The *third* element, or transversals (*coracoids*) are conspicuous, movable, transverse spars, like jib-booms. The *fourth*, &c. § 4, line 4 from below, "*falx tympani*," &c.
„ 814, § 4, Their type, &c. Line 4, *pterygoidea*, &c. § 5, line 7, and fronting, &c. § 7, line 5, "*antrum*" and "*tuberositas* max." Line 5, bel. maxillae, &c.
„ 816, § 3, line 4, cochleæ, strung with a spiral harpsichord of vibratory chords of smooth muscular fibre. § 4, line 3, (inter-vertebral). § 5, line 3, Astræa — Mæandrina, &c.

homologous ones, and analogous features been expropriated by forced loans from settlements otherwise provided for. The component parts of mammarian crania have not been properly identified in the other Orders; so that a true system of *comparative craniology does nowise exist*, *e.g.*, between Mammals and Fishes.

(*a*) In *Embryology*, the "animal" (dorsal) leaf or sheet represents by its median duplicature the dorsal or *neural fissure* from the ethmoid to the caudal bones; and by its ovate border, subsequently clenched together sidewise, in front, the entire *anterior hiatus* from the ethmoidal bones (or the septum) to the anus is produced.

All bones being developed from within this animal sheet symmetrically on either side, it follows that no median series of bones can anteriorly exist except originally conjugate by pairs. The same applies to the dorsal or "neural" sutures. All vertebral blocks consist of a pair of rib-heads of the neural spine (see young hog, &c.) that by a superior and inferior ossification of the primitive (axial and intervertebral) chondroid *discs* are soldered to a central, pentagonal prism, such as we actually find them denuded at the base of the skull and in the odontoid process, *e.g.*, of turtles. The latter prism or process being *supernumerary* to those of the epistrophean and atlas vertebræ, it claims its position as the first (*intercondylar*) *cranial prism; deficient in loco*, so soon as (in Reptiles) the first nuchal vertebra is being slipped forward, out of line, as an *atlas*.

The prismatic centre-piece is originally hollow, as in Fishes, and seems to represent a homologue of the hollow stipe of Crinoids; whereas the joints of corals seem to represent the ossified primitive ("intervertebral") chondroid discs themselves. It hence follows that, *both in the dorsal and frontal mid-line sutures, none but a conjugate series of ossifications can exist;* and that, in all cases, all the occipital as well as sternal organizations, of Mammals, Birds, and Saurians, have to be considered as *bifid* ossifications; as are the *bifid sternal plates* (*or plastron*) *of turtles*,* and the bifid (dorsal as well as ventral) homologous *fins of Fishes*. In turtles, the clavate (*cleidoid*) rib-heads are strictly homologous to those of birds in particular; their sutured plates, or rib-blades proper, expanded and joined into a carapace analogous to the neural one of

* Professor Huxley says, p. 174, § 4, "There are no sternal ribs, and no trace of true sternum has yet been discovered in the *Chelonia*." His "Op. O." fig. 66, is the *petrosal;* "Sq." the *mastoid*, the "Ep. O." of fig. 44 (piscine).

the cranium; while on their free ends (tuberculum) the anguli costarum (the transverse element of each rib) are jointed rearward as in the analogous cephalothorax of the cat-fish, and are symphysized with their partners from the other side across the dorsal mid-line, as by way of analogy the transverse processes of the hips of Mammals (*pubis*) and those of the shoulder of Birds (true *coracoids* or *furcula!* — the well-known "wish-bone") meet across the front suture.

Laterally, the rib-blade carapace of turtles is bordered by a close-knit seam of tabulate, marginal elements; analogously so reproduced in the gill-arches of the cat-fish, as the *fourth* or "cartilage" element. *The fifth conjugate series, or sternum, remains* to be accounted for; and as such we have to claim the plastron, or ventral plates, by mathematical necessity!

A conjugate series of sternal ossicles is likewise present in cases of ectropium cordis and all similar cases of an opening in the anterior mediastinum; as well as in the analogous case of the breast-plates of Crinoids, sea-urchins, and star-fishes. There the bordering digital ribs, *e.g.*, of the (*incurrent*) carniferous lobes or labials ("visceral lobes or arches") of the Asterias aurantiaca conjugately meet from either side, closing over the "rays" (or *interlabial hiatus*) by a duplicate series of so-called sternal ossicles.

(*b*) As for the duplicate (or conjugate) and by no means "odd" (Owen) ossification points of the occipital squama, they are *biseriate, and eight in number.* I have heretofore exhibited the proofs of this fact in a number of fetal skulls. The same squama (called an "odd or supernumerary key-stone" by Owen, and a "supra-occipital" by others) in Fishes forms a porcate, eight-facetted, rhombic plate, which, as in Mammals, is on either side supported by a *trifurcate condylar beam* (called an "ex-occipital"); its head and blade both touching the basal prism (withdrawn in all the *pulmonic*, higher classes to allow of nuchal rotation) and its transversal or jugular process turned rearward (Cyprinoids; buffalo-fish). The occipital neural rib-head is here not developed into a condylar joint — as a matter *of course* — although distinctly present; as likewise in the consecutive petrosal, alisphenoid, optic, and ethmoidal beams respectively.

In young Ruminants (such as the *sheep* for example) the whole temporal attachment (meatus, squama, and mastoid) can be easily severed from the arcuate system of the *barrel-shaped cranium, left entire.* Allowing for the missing cross-divisions of its rhombic

occipital squama (that, however, are easily discovered, *e.g.*, in young Rodents and the infant skull), five consecutive belts are readily distinguished: the condylar, petrosal, alisphenoid, optic, and ethmoid, affording passages for the locomotor, acoustic, sympathetic (glossopharyngeal, dislodged), optic, and olfactory tracts successively and respectively. In Cyprinoids, the same are fully developed in a flight of *five consecutive side-beams.* The top, or vault pieces of the first (condylar) and second (petrosal, *bearing* the semi-imbedded, semi-circular canals) are subsumed in the lower and upper semi-circles of the occipital squama, respectively; and the *true temporal bones we find crosswise inserted, as in Mammals,* between the occipital, petrosal, sphenoidal, frontal, and parietal bones. It is *there we have to look for them, and there we find them!*

(*c*) The temporal fulcrum or attachment in Cyprinoid fishes forms a perfect *simile* to a mammarian hip or pelvis *attached to the neural spine;* the squama (postfrontal) an ileum, so to speak, the dove-tailed meatus-bone an ischium, the conic-crescented mastoid ("epiotic") a pubis, leaving a foramen obturatum of its kind on the temple. The *squama* unites, in forming a temporal *acetabulum* for the reception of the true incus ("tympanic pedicle" or "hyomandibular"), with the true *meatus osseous* [nowhere recognized]!

To the true (ileoid) squama temporalis, overlapping the orbit, we find attached the fifth (crista) ossicle as the zygomatic intercalary of higher animals (Rodents); and behind the prop or meatus-bone the requisite "tuberositas" intercalary (as on the ischium) a little sherd can be easily identified forming a *digastric fossa.*

The piscine temporal attachment has never been properly located or identified by modern comparative anatomists! On the contrary, Owen has drawn on its three main components, the meatus, squama, and mastoid, to frame the supposed requisite "transverse processes" of the cranial neural spine. The former, however, are distinctly located as the *jugular* process of the condylar belt or side-slab; the *otoconite* of the petrosal and the *spinous* sphenoidal processes respectively: all being provided for in their proper places.

(*d*) A simple reference to a fetal or juvenile mammarian pelvis (dog, &c.), and even to that of half-adult Man, will at once suffice to show its *quinque*-partite composition, on either side (apart from the contingent sacral or vertebral axis). It invariably consists of a *prop* or ischium, a *blade* or ileum, a transverse uncinate process or *pubis,* a sejunct *tuber ischii* and a separate *crista ilei,* likewise.

Correspondingly, we find in each perfect shoulder a shoulder-*prop* or clavicle (the pillar-bone of Birds' shoulders); a shoulder-*blade;* a shoulder-*hook* or "coracoid" (transversal); an *acromion*, and a *marginal plate*, as so many separate ossifications, peculiarly prominent in extinct Saurians, &c.

That the shoulder-prop or pillar bone of birds is the *true clavicle*, becomes at once manifest by the comparison with the clavicle of Mammals with a carinate sternum,—such as the mole, &c. It has, however, been viciously interpreted for a "coracoid," and thus become the main source of confusion.

Professor Huxley himself justly insists to claim the pillar-bone of the bird-shoulder as the analogue of the ischium. *The ischium, then, is "the true clavicle of the pelvis."* *Q.E.D.*

The three co-extant "cranial extremities"—the *palato-maxillary*, the *hyo-tympanic* and masseteric or *temporali-mandibular*—have yet to be severally identified and their homologies and analogies properly collocated.

All have a fulcral attachment, of the scapular or coxal (pelvic) type; each consisting, collaterally and respectively, of a prop, a blade, a transverse hook, a ridge and end. The transverse processes of the pelvis and shoulder have been pointed out in the foregoing as the pubis and coracoids respectively, and therefore the extremital levers *cannot* be considered as their "transversals" (as some authors will have it). The shoulder ring of Fishes typifies a pair of disjointed ribs, as it were, each consisting of a skate-shaped *prop* or abutment; a long *blade* meeting its partner underneath by its free end (or "tuberculum costæ," in ribs). It bears a loose transverse spar or coracoid, and is onward joined by a fourth and a fifth piece, the latter suspended from the mastoid (or epiotic) of the temporal fabric. In buffalo-fishes, the analogy of the respective parts of the shoulder with those of an aviary pelvis is striking. In the trout, the analogy of the shoulder-beams to a rib; in the cod, the parallelism of the scapular, opercular, and palatal fabrics *inter se* is very marked.

If in Birds we cause the elbows of a skeleton to meet at the sternum from either side, the *palatal apparatus* of the same bird will form its exact counterpart *in miniature*, by way of analogy.

We here see, at the base of the skull, a stout *prop*—called "*os quadratum*"—issuing into a slanting slab, which, forming an elbow, meets its partner from the other side at the sphenoidal base of the skull,—the part which in Mammals is occupied by the ex-

ternal and internal *pterygoid processes*. Each miniature elbow issues — as seen in large bird-skulls — into two separate slats, as into a radius and an ulna, on a delicate scale. The interior partners become confluent as a *true vomer;* which hence, as in all other cases, is *truly bipartite*.

Cuvier claims the mesial ethmoidal prism of fish-skulls, *i.e.*, the lamina perpendicularis, crista galli, &c., for a vomer. The *hands* to this palatal prehensile are formed by the digital rays, cemented, in Birds, into one solid bill; but completely sejunct in all Fishes, particularly so in the esocine forms.

In all juvenile skulls of large aquatic birds we find the temporal constituents (meatus, squama, and mastoid) all in their respective places as with Mammals.

We likewise find the tympanic ossicles — the incus, malleus, and stapes — all enclosed within the channelled meatus-bone.

We find the *os quadratum* in the place of the external pterygoid process at the base of the skull. *As such we hence have to claim* it, having located all the rest, likewise.

Professor Huxley resumes an old *quid-pro-quo*, by calling the (palatal) quadrate bone by the name of its tympanic neighbor — not homologue — "malleus" [p. 77]. The incus is collaterally present in Birds, likewise, beside the quadrate. Their common temporal (cleidoid) analogue is the meatus-bone.

The shoulder-prop, so to speak, of the palatal abutment, hence, is the *quadrate bone;* its humerus, the internal pterygoid process; its forearm, the semi-vomer and os palatinum respectively.

In Birds, the mandible, being dislodged from the temporal attachment, swings on the palatal prop instead, and this continues down in all the lower Vertebrata; whereby the chelonian "quadrate" can be easily identified as being anchylosed with the meatus.

The palatal prop or os quadratum has a "zygomatic" blade for its (palatal) shoulder-blade, in Fishes provided with a double layer or acromion, so to speak. It is called the "preopercular" bone, and the transverse process thereto belonging is invariably present in the shape of a *hamulus*, wedged in behind the quadrate prop.

In Fishes, as in rattle-snakes, the whole palatal fabric of one side is widely spread apart from its partner of the other side. The cod-fish affords a fine example of the first or humeral spar proceeding from the quadrate prop and issuing into separate *palatal* and *vomeral* slats, widely apart from their partners of the

other side. In snakes, &c., the zygomatic appears agglutinated to the palatal humerus (or internal pterygoid process).

In Fishes, the hyo-tympanic bones remain to be accounted for. We can now safely verify the interpretation given by older comparative anatomists, who claim the tympanic pedicle for an incus, the opercle for a malleus, as a blade; a transverse anterior slat (metapterygoid) for the stapes; the two bones joining or topping off the opercular malleus, as fourth and fifth ossicles, respectively, for a *falx tympani* and true *styloid process*. From the latter propend, in Mammals, the strong hyoid beams; the "opercular fin" whereof we find changed into the concave cartilages the external, internal, and Eustachian ear-ducts, true to the popular interpretation of the opercular apparatus as (true) "*fish-ears*."

(*e*) In Fishes, the component parts of ribs — head, blade, transversal process, the equitant "spinal" series, and the (bifid) mesial-fin series — all remain so many separate *spines* or osseous splinters. The peg, wedge, or cog shaped rib-heads being frequently connate with, or adpressed, or immersed into the hour-glass shaped vertebral prisms, they have been construed into "transverse processes;" whereas they truly represent the *hæmal capitular portions* of vertebral block-pieces; as with higher Vertebrata the *neural* capitula become anchylosed.

(*f*) The gill-arches of Fishes, five in number, represent so many anterior pairs of ribs or cranial hæmal arches, in which, however, the component parts are more massive, and also synchondrosed, as in the ribs of higher animals.

In number they correspond to the *five* cranial neural belts,— (the motor, acoustic, sphenoidal, optic, and olfactory ones). In Fishes three sejunct basal prisms of the cranium are observable: one specially underlying the ethmoidal arches, and forming the true lamina perpendicularis; and one specially underlying the condylar or ex-occipital slabs. In Mammals we find four distinct ones on the cranial base, and a supernumerary one on the spinal column: the odontoid prism or process which claims its true position as the first basal (intercondylar) cranial element. The corresponding five pair of gill-arches, as so many hæmal arches of the cranium, are provided with as many *vascular* (or "*hæmal*") *loops* of veins and arteries. They are essentially distinct from the "visceral lobes," or "visceral arches" (of the embryonic facial hiatus), in which the osseous cranial extremities — the palatal, maxillary, hyo-tympanic

bones, &c. — are developed. *Both the gill-arches and visceral or facial lobes (labials) are collaterally present in Fishes*, as a matter of course.

(*g*) The five vascular loops, encircling the fish-gills, are also perceptible in an embryonic condition, about the thyreoid region in fetal Mammalia, &c., and in adult monstrosities are found developed in the chest (mediastinum) of man. (See Tiedemann's Artery Tables.) The gill-arches themselves are gradually seen transforming into a laryngeal apparatus. The rear arch of Corvina Oscula clearly exhibits the thyreoid form. In turtles, the arch-beams form the incipient frame of a future larynx, respiration being withdrawn from the fringed gills into the glandular lungs.

It is hence evident that the vascular loops or gill-arches can nowise be identified with the "visceral arches," so-called by improper comparison.

A detailed account of the visceral analogies and homologies will be given hereafter, as indicated in last year's paper on "Numeric Relations," &c.

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5. On the Difference between the Animal (Sensual) and the Human (Indagative) Intellect. By Theodore C. Hilgard, of St. Louis, Missouri.

The most comprehensive term descriptive of intelligent capacities is doubtless that which we call *understanding*.

Understanding realizes ultimates from the point of view of principles; effects from that of causes; complex and vital phenomena from that of the *law* or uniform common features, in contradistinction to the specific, particular, or characteristic features.

In all these provinces, embracing the entire domain of *Mathematics*, *Logic*, *Physics*, and *Morality*, the understanding consist in the *genetic construing*, or *developing of the complex from the simple, and of the unknown from the known.*

It is thus a *genetic*, or creatorial, energy of the mind, *comprehending the multiple by the unit.*

Certainly the knowledge of logical cogency, and of hidden causes, for known complex effects; as well as the *analytic discussion*, whether of magnitudes and numbers into factors, or of qualities into simpler *laws*, are entirely alien to the brute intellect.

How, then, is this comprehensive (and hence *comprehensory*) stand-point gained?

If we are to consider physical science (or the judgment of physical impressions and realities) as the construing of effects from primary forces,—or (in default of true principles) from *simpler* effects, called "causes,"—then all associated or complex sensorial impressions require to be resolved (or "analyzed") into optional *component factors* (or *coefficients*, mathematically speaking), to be severally subjected to, and susceptible of, explanatory causes yet to be elicited or "construed."

Whenever we reason from the known to the unknown, there are only two kinds of "premises" possible from which we can proceed in reasoning:—

1. We either proceed from known or granted causes and principles into necessary effects, *i.e.*, ultimates necessarily and with strict cogency thence "following" or flowing. Or—

2. We proceed from given compound cases, requiring the unknown causal explanation yet to be *devised*, suggested or conjectured, and *introduced in order to effect an understanding*.

Ad. 1. In the case of proceeding from granted principles into consequences (the "syllogistic" process), we have, in each step we take, to bring the given principles to *bear upon* such ultimates, so as to cover the case effectually.

This effectual utilizing of the principle by combination, or its synthetic *drift* conducting toward the particular effects held in view, in each case requires its being enacted as a free creation of the human mind.

And when once so conducted as actually to bring the principles effectually *to bear*, it is by *logical test*, trial, proof, or scrutiny that the cogency or logical consistency of such synthetic combinations can be ascertained.

But *Logic* does not itself *create* the argument. The argument, likewise, had first to be conceived or posited, framed or *devised*. If actually brought to bear, it amounts to nothing short of a *logical anticipation*, or a logical "intuition."

The same applies to all mental devices brought to bear in math-

ematical analysis and synthesis, before the actual computation can be carried out.

Ad. 2. In the understanding of sensorial phenomena (or objective reality), we are compelled to proceed from the known compound or complex sensorial fact (as premises) into the (required but) unknown causal explanation.

The explanatory exegesis of given phenomena (*i.e.*, the *intuitive conception of simpler causes*) the English language invariably discriminates from logical deductions, by the term of *an inference.* Practically, an inference is a so-called "hypothesis," suggestively introduced as an *explanatory cause for given facts as premises.*

It is very plain that such is the actual practical distinction held by universal usage as regards "inference," being used to imply any *causal surmise.*

It is the more to be regretted that English and American lexicographers alike have never yet succeeded in discriminating between this special meaning of the word "inference," as distinct from other surmises and conclusions.

A deduction or syllogistic consequence naturally *follows*, conclusively, from granted principles. An inference, on the contrary, has to be made *wherever an explanation has to be supplied.* The distinction is of the highest importance. "Conclusions" are either cogent, consequential ones; or else they are explanatory ones, — optional inferences, *requiring proof*, as being unsafe, and only suggested as possible, but not really demonstrated by way of syllogistic proof.

It is quite essential that safe ground should be held separate from unsafe ground, logical necessities held apart from optional views embraced or suggestively mooted.

And this essential distinction is embodied as a technical term in the English popular diction probably alone among modern languages.

Plausible explanatory suggestions, it may be argued, are mostly derived from analogies. What are analogies? Analogies are *partial identities between different totals.* Animals, it is true, are likewise seen to act as if guided by analogical reasoning. That analogy, however, is a *complex* one, and not actually subjected to an *analysis.* It is thus that "training" becomes possible, by merely accidental, complex associations, typically and permanently impressed on the brute mind, without a discrimination into component factors; *i.e.*, without *supplying* separate, but hidden, *causes*,

or discriminating the necessary features from the accidental or concomitant ones.

If, as we daily do, we supply separate causes, motives, or conditions, by *inference*, we must first be able to discuss or *resolve the whole into separate phenomena*, *i.e.*, into optional, simpler considerations or necessary "categories" of the mind and sensorial perceptions.

It is thus, *e.g.*, that we can resolve our perception of eyesight into the consciousness, *e.g.*, of light, shade, color, and into the judgment of form and distance.

The latter, again, we can construe, on necessary postulates and real conditions given, into an anatomic and geometrical coarrangement, of prismatic fibres conveying light-impressions, with certain muscular or motor fibres, whose separate action thereby appears identified in habitual visual judgment, on the same plan as that of brute training by habitual and unfailing sensorial association.

Therefore, as we cannot introduce the distinctive causal surmise, or inferential explanation — whether by analogy or not — without having first *separated the phenomena* into simpler considerations or categories, it is actually to this peculiar power of *analytic discussion*, or "discrimination" of factors, that we owe the human faculty of conceiving of phenomena by *laws, or simplified, causal points of view.*

It is thus that by discrimination, as a peculiarly human gift, light is introduced into darkness, — intelligence among the sensorial impressions.

An inference or suggested explanation, when once brought to bear so as to cover the ground, and verified by experiment, is *thus far*, and *only thus far*, trustworthy. It is then called "an induction." Induction is inference duly brought to bear and borne out by the event, so far as attempted or carried out.

So long as the supposed cause cannot be *directly* proved to exist, so long the explanation is inferential, hypothetical, and although probably true, *eo ipso* it remains — doubtful.

We are essentially ignorant of the fundamental origin of differences of Quality. When mathematical problems have been resolved to the unit, which is the "key" and measure of all numeric ideas, the truth is intrinsically evident. But whereas we are not yet enabled to trace all causes to the Cause of Causes, wherever *Cause* — *i.e.*, *Quality* — is concerned we have to revert to inferential explanation or so-called "*hypothesis*."

Newton's alleged motto, "*Hypotheses non fingo*," is but a logical or psychological mistake. So long as we cannot prove *why* matter must or should "gravitate," — true though it be, — so long as a presumed *Quality* is involved, so long it remains a true hypothesis! In point of fact, Newton "fixed" the greatest hypothesis yet on record!

Step by step, proceeding from the complex to the simple, the explanatory or *intelligent* idea has to be intuitively created or "anticipated;" not only in the strict sense of scientific investigation, but in the daily occurrences which surround us. That we actually exercise this intuitive discrimination with some degree of success is evident from the fact that we are invariably *surprised* when we discover that we have been "mistaken."

In no other known case the faculty of analytic discrimination, as a fundamentally distinctive property exercised by the human intellect, becomes so supremely evident as in the domain of mathematical reasoning.

Of this faculty we have not yet observed a trace in animal existence. The geometrical operations of the bee remain typically stereotyped, like a physical necessity, not as an intelligent act of conscious mathematical logic.

It is in the particular province of mathematical analytic and synthetic logic, that the proof can be given that there is one inalienable intelligent law or *logical necessity*, independent of individual opinions, sensorial proofs, or personal convictions whatever.

Infinite fractions cannot be rendered sensorially convincing or cogent, because each numeric fraction absorbs the same measure of time, to be realized, represented or expressed. Hence infinite time would be required to prove the possibility or the actual, *finite amount* of any such fraction.

If we could realize all smaller fractions in a time corresponding to their minuteness, we could come to an end in a given time.

It is thus plain that sensorial thinking, or a conscious ideal representation *at a temporal rate*, forms an insurmountable barrier to conceiving of the infinite and the so-called "incommensurable" magnitudes, which are nevertheless strictly gauged by, and dependent on, one another.

For example, as Arago aptly suggests, it is easily demonstrable for all human intelligences — and there is only *one*, uniformly cogent, consistent, and absolutely *impersonal human logos* — that

the diagonal of a geometrical square, called *one*, is the actual geometrical *square root of two;* since a square, erected on such a diagonal, embraces just four halves = two wholes. This cannot be proven to the senses, but only to the *common sense;* which, in this and all true mathematical cases, is absolute and undeniable.

The fundamental boon of Discrimination for the purpose of analytic understanding is chiefly initiated and exercised by a *comparison* of cases submitted. It is the stepping-stone of all science.

Comparison confronts the materials, in order to —

1. Discriminate;
2. Unify the uniform features, as the *law;* and
3. Separate the individual, *distinctive*, or characteristic ones.

Where causes remain *à priori* unknown, as in the Biological Sciences (seeing that *creation of life* lies outside of experiment), we can only operate by eliciting "laws" or uniform fundamental facts and features, and all this in science can only be done by an analytical comparison, *à posteriori;* not by denominational, diagnostic postulates *à priori.*

Now all these branches of the inductive mathematical, the physical, and biological understanding (each of which is inaccessible to the brute mind), are one and all subsumed under the idea of a quantitative, qualitative, and biological *Comparative Analysis of Phenomena*, as the fundamentally distinctive — *discriminative*, *exegetic*, and *creative* — attribute of one intuitive and godlike Mind.

There can be no doubt that animals conceive (and by training can be *made* to conceive) of apparent cause and effect by *contrast.* Contrast, or comparison, simplifies the problem; it brings apparent cause and effect to bear, and in the force of contrast lies the incitement to all discrimination, generally speaking.

Where is the distinctive feature, then, which adapts the human mind to *progress in contrast or analysis?*

It is evidently requisite that there should be a *voluntary memory*, reproducing otherwise vague totalities of experience in categorized forms, as "*cases.*"

It is by voluntary memory that *similar cases can be brought to bear*, to institute the analytic comparison. Cases can be collected, accumulated, discussed, or *assumed*, *without being present to the senses:* at the mental prompting of a *categoric feature.*

Analysis hence can progress by means of mental record lastingly impressed and resuscitated at will or pleasure, *by categories.*

From this *categoric memory*, then, the faculty of *judgment* proceeds.

It is evidently this accumulative, *optional* revival of memory, by "*points*," which is deficient in the animal mind.

It is hence truly predicable that there is a *triune* faculty of the human mind, Will, Memory, and Judgment; the latter proceeding from the two former as a Unit of DISCRIMINATIVE REASON.

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6. On the Oviducts and Embryology of Terebratulina. By Edward S. Morse, of Salem, Massachusetts.

For several years past I have made a special study of the Brachiopoda. The publication of the results of these investigations has been purposely delayed, till I could incontestably demonstrate the genital nature of the Cuvierian hearts, so plainly shown to be oviducts by Hancock and Huxley, and till something at least could be given of the embryology of some brachiopod. For these two matters I have visited Eastport, Maine, for the third time, and now my heretofore fruitless endeavors have been met with success.

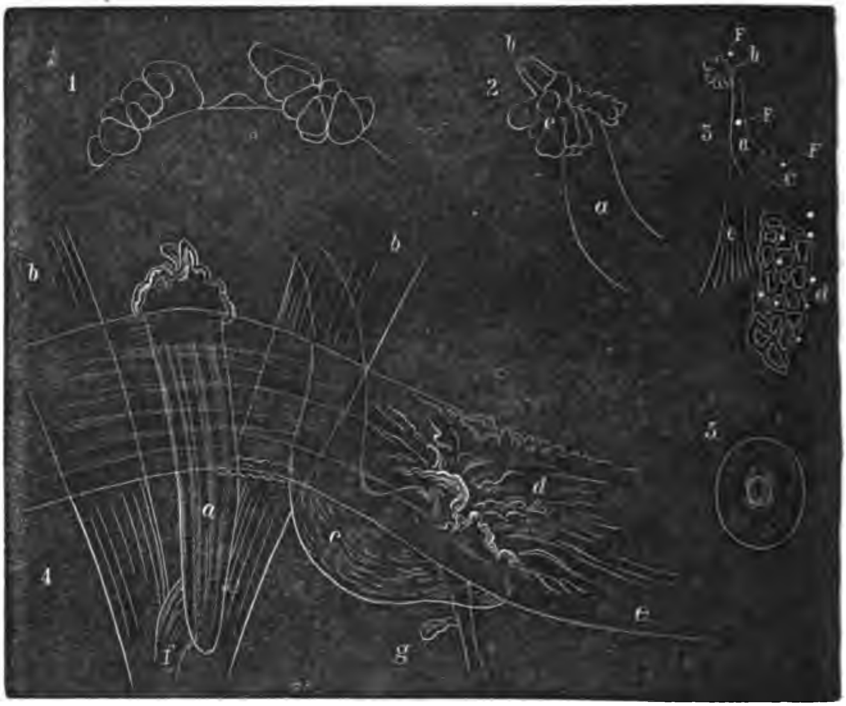
The results of these observations were communicated at the 19th of June Meeting of the Boston Society of Natural History.

I had before seen the ciliary lining of the oviducts in Lingula and Terebratulina, but I wished to see the eggs in their actual passage through the tubes. This I have now repeatedly observed in Terebratulina. The eggs were seen discharged from the sinuses in the pallial membrane, afterward floating freely in the perivisceral cavity; the eggs were then seen gathered at the trumpet-shaped mouth of the oviduct, and have been watched as they were slowly passing through the tube and have been caught as they were discharged at the external orifice. These eggs have then

been followed in their development until they assumed the form of a deeply annulated embryo, composed of four distinct rings, which had a marked vermian contraction upon each other. At this stage they appeared to be attaching themselves by the caudal segment. During the latter part of this examination my embryos were unfortunately lost. I had not the necessary appliances to keep the water at the frigid temperature to which they were accustomed, and the increased temperature of the water led to a rapid development of Paramæcia, and other infusoria, and my poor embryos were ruthlessly eaten up. I have, however, nearly three hundred outlines of the embryos during their development, a few of which are presented with this brief communication. Next year, it is hoped, a complete history of their development will be made, as many things have been observed in their proper management of which I shall profit in my next attempt.

There were also discovered prominent glands at the external openings of the oviducts in Terebratulina, which I have every reason to believe represent the testes. These glands surrounded the external orifice of the oviducts, which protruded somewhat from the anterior walls of the body, and the glands were invariably found filled with spermatozoa.

From Eastport, Maine, I hurried to the St. Lawrence, with the hopes of securing some data regarding the embryology or early stages of another brachiopod found there, *Rhynchonella psittacea.* I was altogether too late for this, but had the pleasure of studying *Rhynchonella alive*, to note the ciliary action in the oviducts driving currents outward, and to establish the correctness of Owen's supposition that the arms of Rhynchonella can be protruded. A jar of specimens dredged by Dr. P. P. Carpenter, who kindly accompanied me from Montreal, was left standing undisturbed for twenty-four hours, when one of the specimens protruded its arms their entire length from the partially opened shells. I poured the sea-water carefully out, and suddenly poured in the strongest alcohol, and the specimen is now preserved in this exerted position.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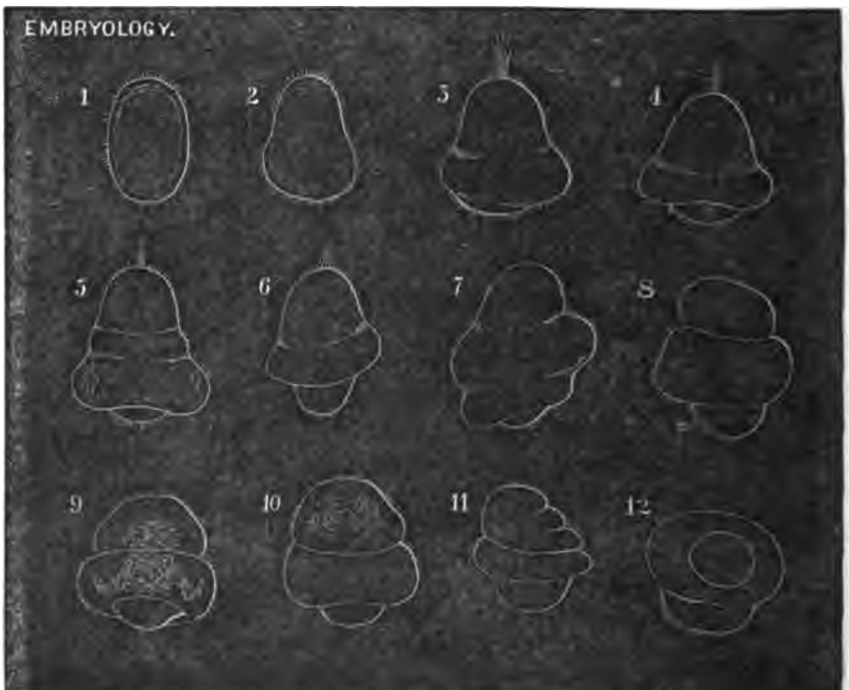
EMBRYOLOGY.
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Explanation of Plate.

Genitals.

Figure 1. Glandular organs supposed to be testes, seen from below.
„ 2. Portion of left oviduct with its relation to the supposed testis. *a.* Oviduct. *b.* Its external opening. *c.* Testis.
„ 3. Left oviduct as it appears from the front through perivisceral wall. *a.* Oviduct. *b.* Its external opening. *c.* Internal opening. *d.* Ovaries in pallial membranes. *e.* Left divaricator muscle. F.F.F. Eggs entering, passing through, and escaping from oviduct.
„ 4. Right oviduct seen from behind. *a.* Intestine. *b b.* Anterior occlusor muscles. *c.* Oviduct. *d.* Internal mouth of oviduct held in the ilio-parietal band, "like a landing net in its loop." *e.* Ilio-parietal band. *f.* Ventral mesentery. *g.* Accessory heart of Hancock.
„ 5. External orifice of oviduct.

Note. — The severed portion of intestine is thrown into folds, in consequence of contraction of the outer wall of intestine.

Embryology.

Figures 1 to 12, showing various stages of embryo.
„ 6 and 8, partial side views.
„ 7 and 11, side view.
Figure 12, partial end view.

III. ETHNOLOGY.

1. Ancient Mounds of Dubuque and its Vicinity. By H. T. Woodman, of Dubuque, Iowa.

The mounds and other ancient earthworks of North America are far more abundant than is generally supposed, from the fact that, while some are quite large, the greater part of them are small and inconspicuous. Along nearly all of our western water-courses that are large enough to be navigated with a canoe, the mounds are almost invariably found, crowning the bare points and headlands of the bluffs which border the narrower valleys, so that when one finds himself in such positions as to command the grand-

est views of our river scenery he may almost always discover that he is standing upon, or in close proximity to, some one or more of these traces of the labors of an ancient people. Some of these mounds can now be seen from the streets of our city, but a greater number have become obscured from view by the encroaching growth of forest trees. Hundreds of them are thus hidden along the valleys and bluffs of our great Mississippi River and its tributaries, but the greater part may yet be traced by careful observation.

It is not only upon the points and headlands that these mounds are found, but they also exist in great numbers upon the broader, upper terraces in the valleys.

The terraces are such as Professor White refers to the Terrace Epoch, having doubtless been ancient flood-plains of the adjacent streams; but they are now far above the reach of their highest floods. They furnish the most convenient sites for the valley towns of the white race, and we often find that convenience or sentiment had induced the mound-builders also to choose precisely the same sites for their earthworks. The result is that a large number of mounds in such positions are not only obscured by the growing towns, but are ruthlessly destroyed every year.

It is for this reason that I wish to call the attention of this Association to some of the mounds that once occupied, and now in part occupy, the ground in and around the city of Dubuque, and to preserve in its publications a record of them; but it is not my purpose to enter into any discussion of their origin nor of the uses for which they were constructed.

Large numbers of these mounds have been destroyed by the building of our city: how many I do not know, for it is true that a majority of persons do not recognize their true character even if living in daily contact with them. Indeed, so far as I know, no person had either publicly or privately recognized the group I am about to describe, although located within the corporate limits of our city, until they were discovered by myself, and their existence made known to the public through the medium of one of our newspapers only a few months ago. This group is located within the northern limit of the city, adjacent to the narrow body of water known by the local name of Lake Peosta, and about fifty feet above its surface.

They are circular, or nearly so, except the three larger ones along the edge of the terrace facing the east, the Mississippi River

and the lake before mentioned. They are almost invariably fifteen paces apart from centre to centre, the smaller ones being from two to two and a half feet high and about twenty feet in diameter. The material of which they are composed is the ordinary alluvial soil of the terrace. They are seventy in number, and are now shaded by a pleasant oak grove of comparatively recent growth.

What is most remarkable about this group of mounds is their number and the great regularity of their arrangement, being arranged in straight or slightly curved lines (some of them being parallel), and their nearly uniform distance apart, namely, about fifteen paces.

That the shape, size, and position of the larger mounds in relation to the others, together with the arrangement of nearly all in lines with almost uniform interspaces, formed part of the plan of their builders, cannot be doubted; but the knowledge as to what that plan had reference doubtless perished with those that constructed them.

No other traces of man or his works have as yet been discovered in connection with them, but only a few rods to the northward and eastward of the limits of the group I discovered fragments of the ancient pottery and several flint arrow-heads some years ago.

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2. On Certain Peculiarities in the Crania of the Mound-Builders. By J. W. Foster, of Chicago, Illinois.

While the individual variations in the crania of a particular race are so great as to present intermediate gradations all the way from one extreme to another, thus forming a connecting link between widely separated races, yet, in a large assemblage of skulls, derived from a particular race, there is a general conformation, a predominant type, which appears to have been constant as far back as human records extend; to have been unaffected by food, climate, or personal pursuits; and which has been regarded among the surest guides in tracing ethnic affinities. Hitherto our knowl-

edge of the Mound-builders' crania has been exceedingly scant,— restricted to less than a dozen specimens, which, if authentic, clearly indicate for the most part the Indian type. The results of my observations, made at different points, have led me to infer that they were characterized by a general conformation of parts, which clearly separated them from the existing races of man, and particularly from the Indians of North America.

I propose to discuss these distinctive characters, based on crania derived from points somewhat widely asunder:

I. From the region of Chicago, Illinois.
II. From the region of Merom, Indiana.
III. From the region of Dubuque, Iowa.

The similarity of type in these crania, apart from the similarity in weapons of warfare, pottery, personal ornaments, and earthworks, would indicate a homogeneous people distributed over a wide area.

I. From the Region of Chicago.

A portion of the crania described in this paper was collected from two groups of low mounds about five miles apart, situated on the banks of the Des Plaines River. Dr. Stimpson — now deceased, but whose memory will be honored by every cultivator of science in this country — was first attracted to one of these groups by observing circular trenches investing knolls two and one-half feet above the surrounding plain, which led him to believe that they were artificial; and, under his direction, Mr. Charles Kennicott, assisted by Dr. Durham, entered upon their exploration. There were portions of eleven skeletons found in the first group, but they were so far decayed that only one skull and three frontal bones sufficiently well preserved to admit of measurement and comparison were obtained.

The other group of mounds, situated near Haas's Park, yielded human remains which evidently belonged to two distinct epochs. In them were found well-marked Indian skulls, in a condition slightly changed, and two skulls evidently belonging to Half-breeds,— thus showing that, up to a comparatively recent time, these mounds had been used as places of sepulture by different races. In addition to these evidences of recent entombment, were found, far gone in decomposition, quite a number of crania presenting features which readily distinguished them from those of the Indian and Half-breed. These relics have a high value,

as without doubt they are the authentic skulls of the mound-builders.

The best preserved skull belonging to this pre-historic race was taken from what is called "Stimpson's Mound," one of the group first described. The gelatinous matter had been dissolved away; and the bony matter, as saturated with moisture, presented a soft spongy mass, exceedingly fragile, which, when dried, readily adhered to the tongue. The soil was not unfavorable to the

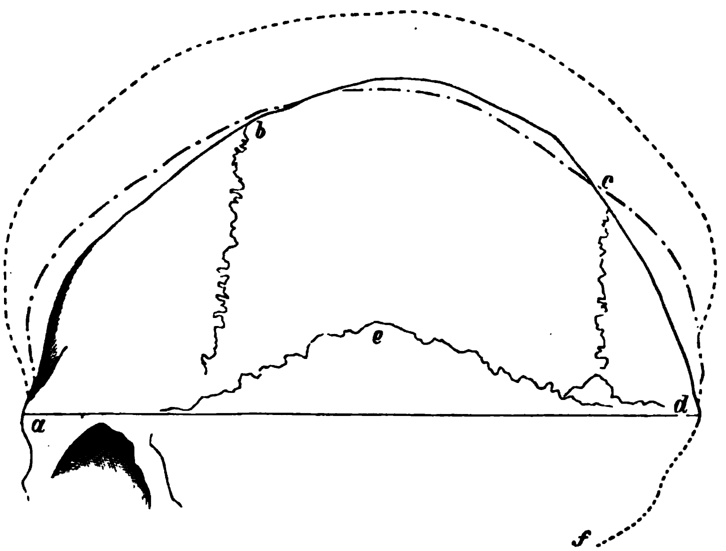

Fig. 1 = ½. — Skull from Stimpson's Mound.*

a Superciliary ridge and glabella.
b Coronal suture.
c Apex of lambdoidal suture.
d Occipital protuberance.
e Squamosal suture.
f Position of the foramen magnum.†

preservation of human remains, being a fine loam which, when packed, resisted the leaching of the waters. To these remains, then, we may assign a very considerable antiquity.

* The dotted line inside shows the contour of the Australian skull — the lowest of existing races; the outer dotted line, that of the European, — the highest.

† As these points, in the subsequent illustrations, will bear the same letters, the names will not be repeated.

This skull is imperfect, the left parietal being wanting, and also the base, and therefore will not be the subject of minute description. There are, however, a few general points displayed, which will be found characteristic to a greater or less degree of the crania subsequently represented, to which I would direct attention:

1. The low development, both in the anterior and posterior regions at the apex of the coronal (*b*) and that of the lambdoidal suture (*c*), as well as the low frontal eminences, whereby the form of the *Gothic arch* is given to the profile view.

2. The obliquity of the line which starts from behind the foramen magnum, and runs to the occipital crest (*b*).

3. The tendency at the union between the parietal and squamous bone (*e*) towards a straight line.

4. The projection of the nasal bones beyond the general outline of the skull.

5. The occipital crest as forming the posterior extremity of the skull.

6. The vertical parietal walls, the deeply notched orbital processes, and the bulging out of the zygomatic arches (not represented in the figure) in an extraordinary degree, as compared with the European skull.

Many of these characteristics, which are not conspicuous in a well-developed European skull, indicate an approach towards the lower animals of the anthropoid type; but still, between the lowest form of the one and the highest form of the other, there is a broad chasm which cannot be spanned by intermediate gradations.

The measurements of this skull will be given in a tabulated form. In its general outline it is Orthocephalic. In brain capacity it is about that of the Borreby skull of Denmark,—figured by Huxley,—which is referred to the Stone Age; a time just succeeding the last great physical changes in Europe, and when Man was the contemporary of the Urus and Bison, but not of the Hairy Elephant and Rhinoceros. This Danish skull, with the exception of the famous Neanderthal skull, is of the lowest conformation yet observed in Europe; and, when compared with the Stimpson skull, there will be found a striking parallelism in their general outlines,—the latter rising a little higher at the vertex, and receding a little in the region of the superciliary ridges, and at the base in the line of *d f.* While other Danish skulls of the Stone

Age exhibit a higher development, other mound-builders' skulls, as I shall show, are more depressed.

The "Kennicott Mound" yielded three frontal bones,—the only parts of the skeleton capable of preservation,—which were also indicative of a low type. In two instances there was a rapid narrowing in the temporal region; the plates were extraordinarily thick; the superciliary ridges were massive, standing out like ropes; the orbital processes were profoundly notched; and the frontal bone was much prolonged towards the coronal suture. Fig. 2, reduced one-half, represents one of these bones. No one, I think, can view this fragment of a skull, with the superciliary

Fig. 2.—Frontal portion of a skull from "Kennicott's Mound," near Chicago.

a a Superciliary ridges.
b Coronal suture.

ridges projecting far beyond the general contour, both laterally and in front, and the low, flat forehead, with its thick, bony walls, without coming to the conclusion that its possessor was a ferocious brute. The prize-fighter of this day might envy such a frontispiece, adapted to withstand any amount of pommelling, or almost even to turn a musket-ball.

The Haas's Park mounds yielded two crania, which were too imperfect to give all the salient points. One is represented by a part of the frontal and parietal bones, and is characterized by the almost entire absence of a forehead. The nasal bones are pro-

longed from the point of union with the frontal bones, like the beak of a bird, or the superior jaw of a gar-pike. The bony plates are of almost pasteboard thinness; the orbital rings are sharp and delicate; the sutures are imperfectly joined; and there is an absence of frontal sinuses, which are supposed to be formed only after puberty,—so that the skull evidently belonged to a young person.

This is, undoubtedly, the most remarkable skull hitherto observed, affording the nearest approximation to the anthropoid forms. It is so far anomalous that I shall hereafter omit to compare it with existing types. Granting all of the effects of pressure,

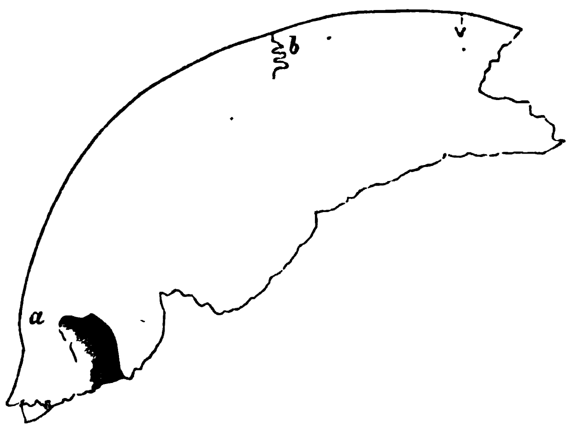

Fig. 8 = ½.—Child's skull, from Haas's Park.

a Glabella.
b Coronal suture.
v Vertex.

whether artificially applied or the result of superincumbent earth after burial, still it is difficult to bring it within the reasonable bounds of conjecture as to our ideas of the conformation of what a human cranium, in its widest deviation from a supposed type, ought to be.

There was another skull, fragmentary in character, having about the same contour as that from the "Stimpson Mound," which I have not deemed it necessary to figure.*

* That portion of this paper descriptive of the mound-builders' skulls found in the valley of the Des Plaines, and the generalization as to the former exist

II. From the Mounds in the Region of Merom, Indiana.

For the skulls recovered in the exploration of these mounds I am indebted to Dr. H. F. Harper, of that place, who very kindly placed them in my possession.

This skull has about the same brain capacity as that from Stimpson's Mound (Fig. 1), rising a little higher in the vertical region,

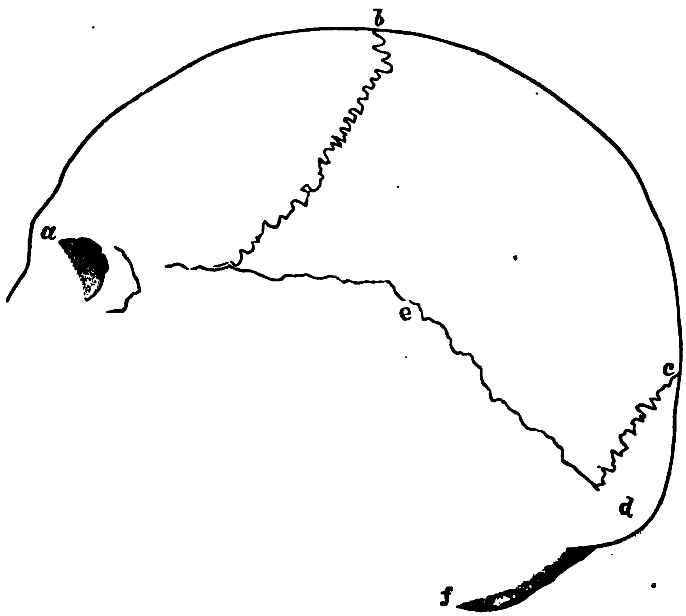

Fig. 4 = ½. — Profile view of a mound-builder's skull, from Merom, Indiana.

and bulging out at the frontal eminences and supra-orbital ridges. It is a good illustration of what I regard as typical of the mound-builder's skull, — the *Gothic arch* outline; the very considerable

ence on this Continent of an anomalous race, characterized by a remarkably depressed forehead, was submitted by me to the Chicago Academy of Sciences, in the winter of 1869–70; and the subsequent discoveries which have been made but confirm me in the views originally entertained as to the low type of the mound-builders' skulls. The specimens unfortunately perished in the great fire of October 8, 1871.

space between the occipital crest and foramen magnum; the approach in the squamosal suture to a horizontal line; and the great development of the occipital crest, forming the extreme posterior part. The back view shows the *pyramidal* form, caused by the flattening of the parietal plates; and the zygomatic arches, as seen in the vertical view (not represented), sweep out beyond the general contour.

In Figure 5, the frontal eminences are more conspicuous; the superciliary ridges are less developed; the space between the

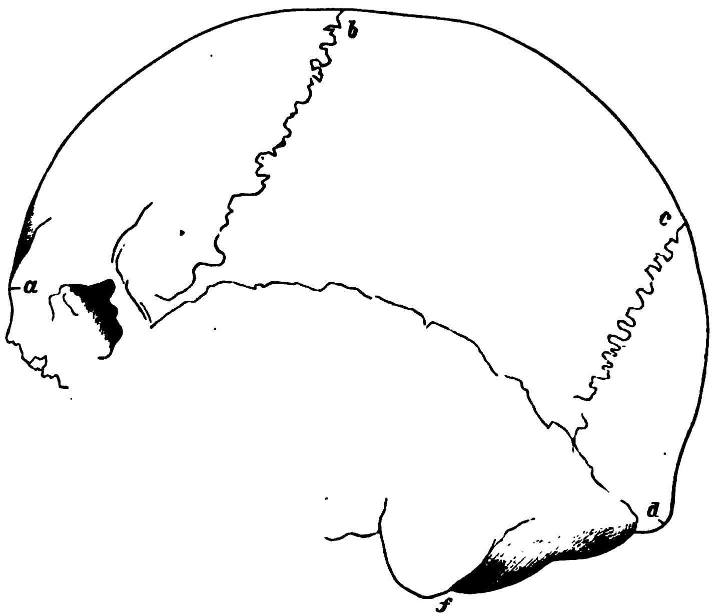

Fig. 5 = ½. — Profile of mound-builder's skull, from Merom, Indiana.

foramen magnum and occipital crest is less; but still the latter point forms the posterior extremity, and the squamosal suture approaches a straight line.

If we regard a high forehead as the index of mental power, — a feature which is due to the retreat of the facial bones, and therefore indicating a divergence in the development in these parts from the corresponding parts in the lower animals, — we have in Fig. 5, an example intellectually above those previously described. The

facial angle is less acute, and the brain capacity is greater; but still, in these respects, this skull falls far below that of the average Teuton.

Fig. 6 differs from the preceding illustrations, being of a less elongated form, but has other characteristics which link it to the race of mound-builders, such as the wide interval between the points *d f*, and its posterior occipito-extremity. The frontal sinuses are inconspicuous; and there is a deficiency of development, judged by the European standard, in the frontal and

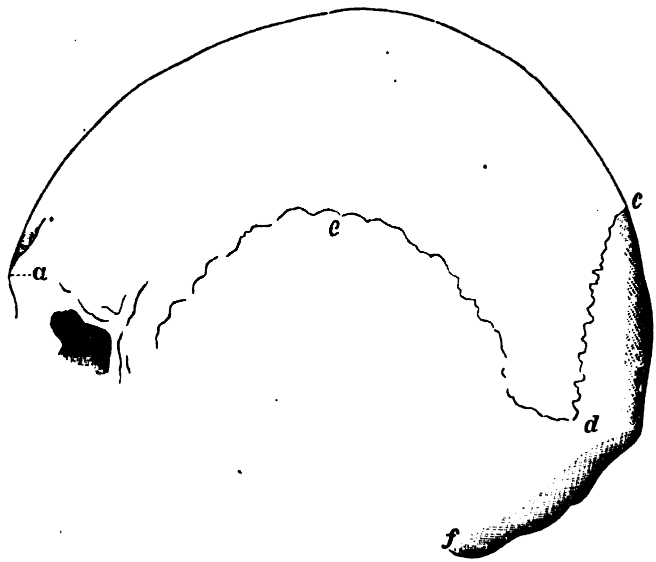

Fig. 6 = ¼. — Profile of a mound-builder's skull, from Merom, Indiana.

parietal regions. That it belonged to a mature individual is inferred from the fact that the coronal suture is nearly obliterated. The parietal walls are flattened, and the vault is pyramidal. The left lobe of the cerebrum is unduly developed, as will be seen by reference to the vertical view (Fig. 14), but not more so than is to be seen in European skulls at this day.

In Fig. 7, representing the fragmentary portion of a skull, extending from the posterior margin of the foramen magnum to the coronal suture, we have a lower development than in the famous Borreby skull from Denmark.

In the posterior view (Fig. 8), it will be seen that there is an extra suture just above the occipital ridge, c 1, giving origin to what anatomists call the *Ossa Wormensia.* This peculiarity I observe in the skull of a Flathead now before me, and traces of the former existence of such a suture I detect in many of the mound-builders' skulls which I have figured. While this Wormian bone is not uncommon in European skulls, it is an interesting inquiry whether it is not of more frequent occurrence in the lower races of mankind.

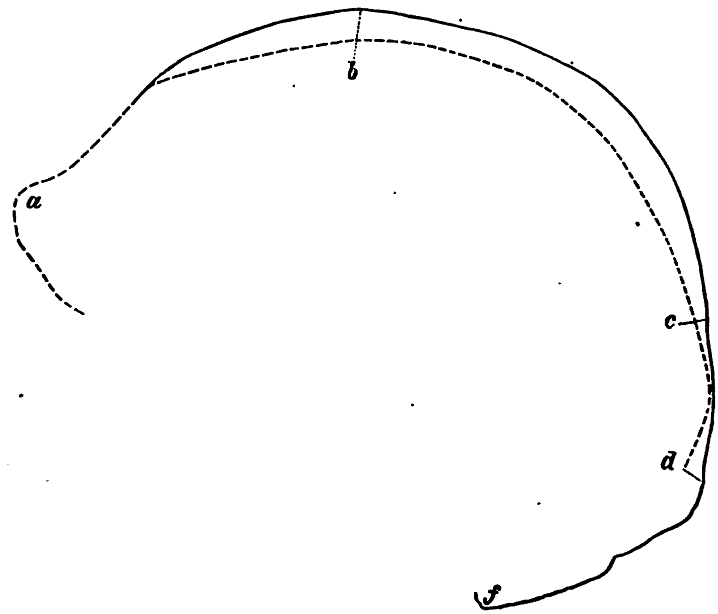

Fig. 7 = ½. —Fragment of a mound-builder's skull, from Merom, Indiana.*

The above profile views of four skulls from this region have certain points of resemblance among themselves, and also as compared with those which I have already described.

When my attention was first directed to these low forms, I tried to argue that they were the result of artificial pressure, or that, in their long entombment, they had become warped and distorted. Had I seen but a single specimen, I might have said that

* The dotted line represents the contour of the Neanderthal skull.

it was anomalous, that it belonged to an idiot; but when I find the same typical characters pervading the crania from widely separated points, and that in their outlines they are symmetrical, I am led to the irresistible conclusion that these characters are congenital.*

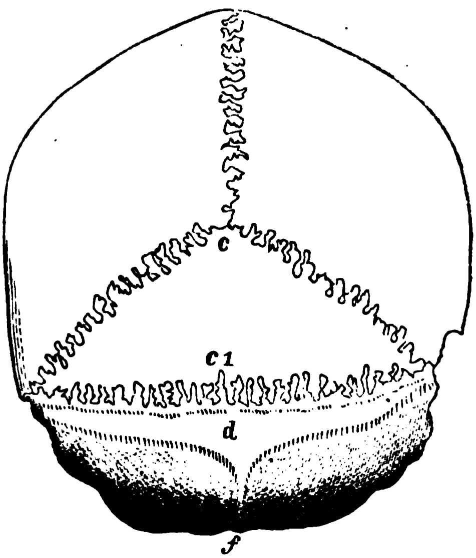

Fig. 8 = ½. — Posterior view of the same, showing the "Ossa Wormensia."

In the exploration of the mounds in the valley of the Kankakee, near Laporte, Indiana, by a party of which Dr. Higday formed one, a single cranium only was taken out entire, which he regards in some respects as remarkable.

"Anteriorly," he remarks, "this skull is not only very low, but

* I have but a single specimen — from Merom — which clearly shows the effects of artificial pressure. It is a large skull, and a flattened plane occupies the space between the occipital crest and the vertex. The surface for the muscular attachments, unlike most of the other specimens, is very much roughened. Whether this flattening resulted accidentally from strapping to the cradle-board in infancy, or from pressure deliberately applied, I am not prepared to say; perhaps the latter. In this case the flattening is in the occipital region, and therefore entirely different from the usage which prevails among the Flatheads of the North-west Coast. This flattening has given an undue expansion to the parietals, amounting to a deformity.

also extremely narrow; while posteriorly the space of the cerebellum is very much depressed and small, the occipital bone being flattened from its base upwards and forwards, so as to encroach greatly on the space which in well-developed skulls is occupied by the posterior lobes of the cerebrum. The extremely deficient development, which can be much better appreciated by an examination than by a description, explains the possibility of a skull having at once diameters of such respectable length and capacity, and yet being so extremely small (sixty inches). That this skull is that of an adult, is evident from the parietal consolidation of some of its sutures; and that it is not a dwarf or an idiot, we must infer from its possessor having had the honor of a mound being built over his remains." *

III. From the Mounds in the Region of Dubuque, Iowa.

The mounds in this vicinity are by no means conspicuous in size, and are destitute of those long lines of circumvallation which so often invest those of the Ohio Valley.

During the present session of the American Association for the Advancement of Science (1872), at this place, several of these mounds have been opened, and have yielded the remains of human skeletons far gone in decomposition. Three skulls were secured sufficiently preserved to afford a correct idea of their contours, one of which passed into the possession of Mr. Oliver N. Ryan, of Marshall Hall, Maryland, and two were secured by Mr. F. W. Putnam, of the "American Naturalist." Mr. Ryan has kindly furnished me the data for describing the skull in his possession. It was exhumed by Dr. Augustus Campbell, of Dubuque, from a mound about twelve feet high, at Dunleith, Illinois, opposite that city. The corpse was buried about two feet below the surface, and was covered with wood and stone. Appended is a figure of this skull, which is one of the most anomalous ever found.

Although this skull is fragmentary, sufficient remains to enable us to protract its general outlines. In brain capacity it is as low as the Neanderthal skull; and that it belonged to a mature individual is inferred from the fact that all the sutures are closed. It differs from the Neanderthal skull in this: that while in the former there is a prodigious development of the superciliary ridges,

* Proceedings Chicago Academy of Sciences, 1870.

such as have never before been observed in a human cranium, in the latter they are not unduly prominent. It has a marked resemblance in its contour to that from Haas's Park, near Chicago (Fig. 3), but is a little more depressed in the frontal region. The nasal bones, as in that specimen, form a bird-like appendage, though not quite so conspicuously marked.

The Neanderthal skull, it need hardly be observed, affords the nearest approach hitherto observed to the confines of that gulf which separates man from the anthropoid types.*

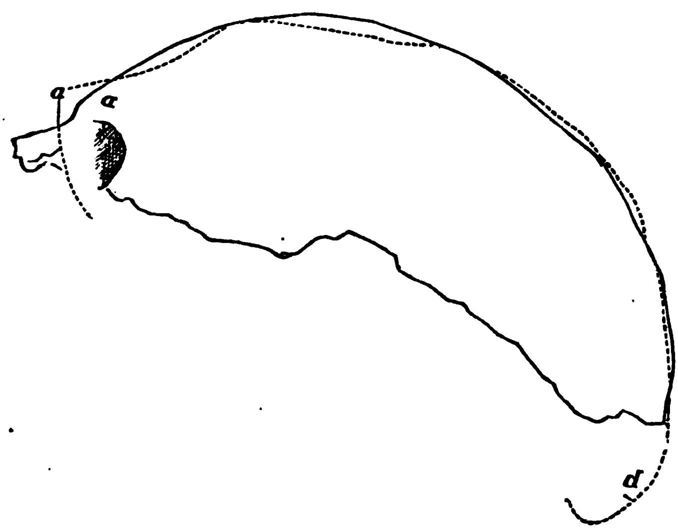

Fig. 9 = ½. — Fragment of a mound-builder's skull, from Dunleith, Illinois.†

* As this paper is passing through the press I acknowledge the receipt of photographs of two characteristic mound-builders' skulls, preserved at Milwaukee, with a descriptive note, from my valued friend Dr. Lapham. This testimony as to the former existence of an anomalous race by so cool and accurate an observer as Dr. L., I regard the more valuable, since he was inclined to believe, in his "Antiquities of Wisconsin," that the mounds were heaped up by the ancestors of the Redman.

"Two skulls of the ancient mound-builders, preserved at Milwaukee, possess characteristics confirming the views lately advanced by you, first at the Meeting of the American Association for the Advancement of Science, at Dubuque, 1872, and again in the 'American Naturalist' for December. One of these skulls, from a mound at Wauwatasa, has a breadth of seventy-eight per cent of

† The dotted line represents the outline of the Neanderthal skull.

In a review of this nature courtesy requires that I recognize the labors of my predecessors; and I must say that, with a single exception, in the figures heretofore given of mound-builders' skulls I fail to recognize the *typical* characters. Squier and Davis, in their admirable work, profess to have collected but one skull which they regarded as authentic of the mound-builders, but any comparative anatomist, on referring to their plate, will instantly recognize it as of the Indian type.

Dr. Morton justly describes it as "perhaps the most admirably formed head of the American race hitherto discovered. It possesses the national characteristics in perfection, as seen in the elevated vertex, flattened occiput, great interparietal diameter, ponderous bony structure, salient nose, large jaws, and broad face." *

Comparing this skull with those which I have figured, it will be seen that the Scioto skull differs widely from the true mound-builder's skull in its most characteristic features.

Morton gives figures of two supposed mound-builders' skulls, one of which was furnished by the late Dr. Troost from a mound

its length, and would be ranked as *Orthocephalic*, or regularly formed head. It is so much flattened behind as to suggest the possibility of artificial compression when young. The other skull has a breadth of only seventy per cent of its length, and therefore ranks as a *Dolicocephalic*, or long-head. The peculiar characteristics, indicating a low grade of humanity common to both, are a low forehead, prominent superciliary ridges, the zygomatic arches swelling out beyond the walls of the skull, and especially the prominence of the occipital ridge. The anterior portion of these skulls, besides being low, is much narrowed, giving the outline, as seen from above, of an ovate form.

"It seems quite probable that men with skulls of this low grade were the most ancient upon this Continent; that they were the first to heap up those curiously shaped mounds of earth which now so much puzzle the antiquary; that they were gradually superseded and crowded out by a superior race, who adopting many of their customs continued to build mounds and to bury their dead in mounds already built. Hence we find mound-builders with skulls of this ancient form associated with others of more modern type.

"The discovery of these skulls with characteristics so much like those of the most ancient of pre-historic types of Europe would seem to indicate that if America was peopled by emigration from the Old World, that event must have taken place at a very early time,—far back of any of which we have any record." — *Private Correspondence*.

I regret that I cannot give figures of these skulls, but hope to be able to do so hereafter.

* Morton, Crania Americana, p. 220, pl. xxxix.

near the junction of the Broad, French, and Holstein Rivers in Tennessee, represented in Figure 10.

This skull is remarkable for its great vertical and parietal diameter and its elevated occiput, characters which do not belong to

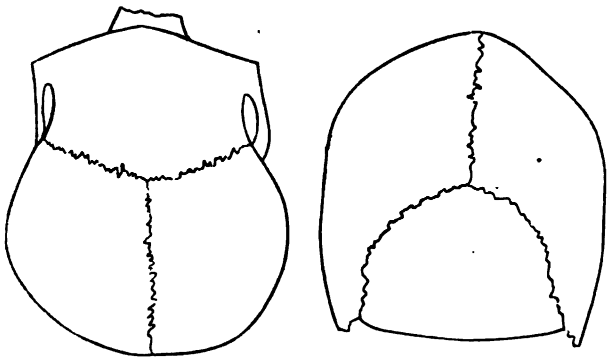

Fig. 10 = ¼. — Supposed mound-builder's skull from Tennessee.

the skulls which I have described. The following are the measurements: longitudinal diameter, 6.6 inches; parietal, 5.6; frontal, 4.1; vertical, 5.6; internal capacity, 87.5 cubic inches. The left

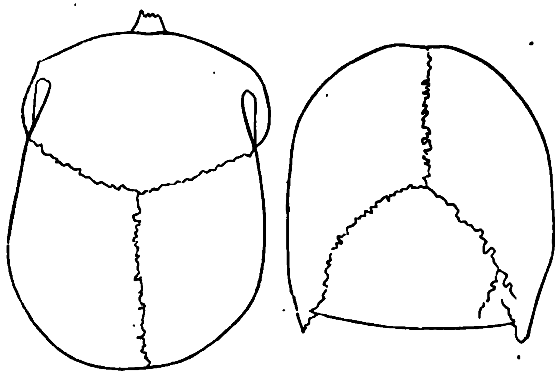

Fig. 11 = ¼. — Supposed mound-builder's skull from the Upper Mississippi.

portion of the middle lobe of the brain-case is distorted, which may have resulted from the individual, in infancy, having been strapped to a cradle-board.

The second example, given by Morton,* is of a skull from a mound on the upper Mississippi, one hundred and fifty miles above the mouth of the Missouri, represented in Fig. 11.

The skull from the Grave Creek Mound, West Virginia, figured by Morton and reproduced in Schoolcraft's work, is of the Indian type.

Lapham, in his "Antiquities of Wisconsin," has figured a skull from a mound, which has some of the characteristics of the Flat-head.

Classification of Skulls.

In the classification of skulls, comprehending the relation of breadth to length, those which are less than seventy-three to one

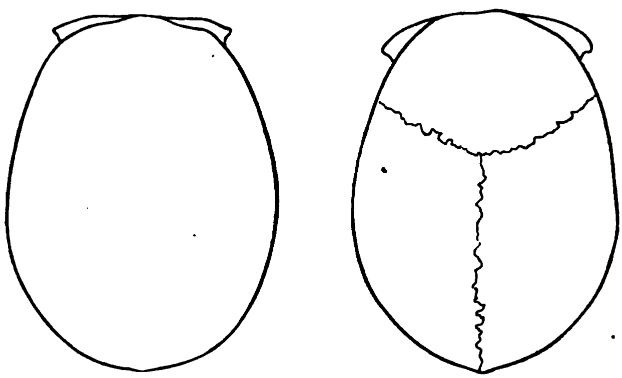

Fig. 12. Fig. 13.

Vertical views of mound-builders' skulls, from Merom, Indiana.

hundred are called long, or *Dolicocephalic;* those whose proportions are less than seventy-four and seventy-nine to one hundred are medium, or *Orthocephalic;* and those whose proportions reach eighty and eighty-nine to one hundred are *Brachycephalic.* The mound-builders' skulls which I have examined differ on the one hand from the Indian type, which is *Brachycephalic,* and from the Teutonic, on the other, which is *Dolicocephalic.* They are intermediate, or *Orthocephalic,* as will be apparent from the above figures, reduced to one-fourth the natural size.

Fig. 12 is a vertical view of the skull represented in Fig. 4, and Fig. 13 of that represented in Fig. 5. The vertical view repre-

* Ibidem, p. 229, pl. vi.

sented in Fig. 14 is the skull represented in Fig. 6. The latter approaches the short-head form; and while the corresponding walls are not symmetrical, there is nothing to indicate artificial distortion. In Figs. 12 and 13 the relation of breadth to length is about seventy-three to one hundred, and in Fig. 14 it reaches seventy-four to one hundred. This ellipsoïdal form, or, in other words, this deviation from the great interparietal diameter, which is characteristic of the Indian type, and which gives to the savage his ferocious and untamable character, is a broad distinction which cannot be overlooked. From these examples of a want of conformity in craniological development, apart from other evidences,

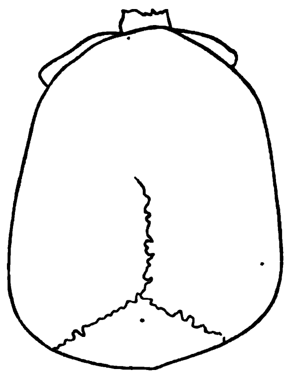

Fig. 14.—From Merom, Indiana.

I think we are justified in drawing the conclusion that the mound-builders were not the ancestors of the North American Indians.

The question arises, whether this singular conformation of skull is congenital, or the result of artificial pressure. We know that the Flatheads and Chenooks of the Columbia River indulge in this usage at the present day, and there is reason to believe that other tribes did formerly. But with regard to the mound-builders' skulls, it may be said that, while the volume of the brain is small, the brain-case is as symmetrical as that of the European. Where artificial pressure is resorted to, as pointed out by Morton, the brain in volume is not diminished, but is extraordinarily developed in those parts of the case where the pressure is not applied, and hence we have the most grotesque distortions. The course of every bandage is marked by a corresponding cavity in the bony

structure. This is illustrated in the following figure, the original of which was furnished me by Dr. W. H. Boyd.

The distortion of this skull, as seen in the profile, is enormous; but in the vertical view, not given, it is still more exaggerated, the left parietal wall bulging out like a great tumor. There were apparently two bandages applied to effect this distortion, — one across the frontal bone, just above the superciliary ridges, and one just back of the coronal suture.

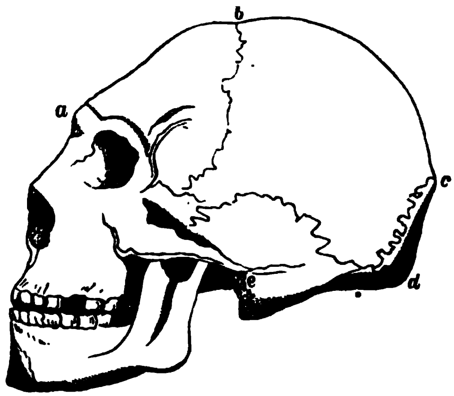

Fig. 15 = ½. — Skull of a Flathead, in the Museum of the Chicago Medical College.

Distinctive Characters.

The skulls which I have described possess peculiarities which ally them more nearly with the Mongolian race than with the Negro or European. They belong in one respect to what Dr. Prichard calls the *Pyramidal type*, but in other respects they present characters which are *sui generis*. The pyramidal form, seen in cross section, arises from the peculiar conformation of the malar bones, giving an outward sweep to the zygomatic arches.

I append a synopsis of what I regard as the distinctive characters of the mound-builder's skull, selecting for the purpose the one represented by Fig. 4, which belongs to neither the lowest nor the highest forms; and that the reader may compare these peculiarities with those of the idiot, as given by Humphry, I shall, as

far as convenient, follow his order of description.* It is to be regretted that in all my specimens, with a single exception, the facial bones are wanting.

In examining this skull in its general outlines the observer is struck by the scantiness of brain capacity, seen in the narrow forehead, the receding frontal bone, and a similar recession in the region of the lambdoidal suture, which give to the vertex an undue prominence, and to the longitudinal arc an outline approaching in form a Gothic arch.

That portion of the occipital bone behind the foramen magnum, instead of being continued in a nearly straight line, as seen in the European skull, curves up to the occipital crest. The occipital condyles are small, and "the basilar portion of the occipital bone ascends with unusual obliquity from them." "The foramen magnum and the other foramina for nerves at the base are comparatively large; the foramina for vessels, as well as the grooves for the sinuses, are, on the other hand, comparatively small." The post-glenoid process, as in the Negro, is strongly marked; the occipital crest is highly ridged, and arched convexly like the figure ⌒⌒, and the point where these arches intersect forms

* "The skull of the idiot," says Humphry, "presents in many respects an approximation to the skull of the lower animals, especially that of the ape, in the following particulars: the facial bones are proportionately large; the brain case is contracted in every direction, more particularly in front and above, causing lowness and narrowness of the forehead, but also behind and below; the space behind the foramen magnum is small, and the bone slopes obliquely upward from it to the occipital crest; the foramen itself partakes somewhat of this slant; the occipital condyles are small and preternaturally convex, and the basilar portion of the occipital bone ascends with unusual obliquity from them; the temporal fossæ are deep; the temporal ridge is well marked and ascends to a comparatively high level, and this, together with the flattening of the parietal bones, and the prominence of their sagittal portion, constitutes an approximation to a 'sagittal crest.' The line of union of the temporal with the parietal bones is straighter than usual, and the post-glenoid process is rather more marked. The frontal bone projects far backward, in the situation of the anterior fontanelle between the parietals; the posterior and middle cerebral fossæ are shallow. . . . The foramen magnum and the other foramina for nerves are comparatively large; the foramina for vessels, as well as the grooves for the sinuses are, on the other hand, comparatively small. The cranial bones are generally thick, and the sutures early obliterated.

"The orbits are comparatively large, their anterior outlines are oblique, and the superciliary ridges prominent and project beyond the general width of the cranium."—*A Treatise on the Human Skeleton*, by G. W. Humphry, Lecturer on Surgery, in the Cambridge, England, University Medical School, p. 288.

the extremity of the skull; the temporal fossæ are deep, and the temporal ridge is prominent; the apex is about midway between the coronal and lambdoidal suture; the parietal plates, instead of swelling into a rounded outline, are flattened; the suture connecting the squamous bones with the parietal is less convex than in the European, and in this respect approaches that of the chimpanzee and the lower animals, in whom it is nearly straight; the superciliary ridges are strongly marked, and project beyond the general contour of the brain-case; and the glabella forms the extreme point of the anterior portion of the skull. The orbits, where bounded by the superciliary ridges and the nasal septum, owing to the deep supra-orbital notch, are of a quadrangular shape; the frontal eminences are very slight, which makes the superciliary ridges more conspicuous and the forehead more retreating; and the zygomatic arches swell out beyond the parietal walls, which in the European skull so far overhang as to conceal them in the vertical view. From this point of observation it may be said that all the exterior prominences are visible, — the occipital protuberance, the zygomatic arches, and the superciliary ridges.

The frontal bone is of great strength, and slopes backward, encroaching on the parietals, and giving origin to a low forehead. In the lower animals this bone becomes nearly horizontal, and is placed behind the eyes. "In proportion," says Humphry, "as the cranial portion slopes backward, so do its facial buttresses — the nasal and angular processes — slant forwards; and in proportion as the brain is well developed, and the cranial part of the bone is upright, so are the facial processes directed perpendicularly downwards. In the lower animals, for instance, they grow directly forwards, in the lower races of mankind they grow downwards and forwards, and in the best formed human skulls they grow almost vertically downwards."

Such are the characters which seem to predominate in the mound-builders' skulls, — characters which distinguish them from the Negro on one hand and the Teuton on the other. Individual variations occur, as might be expected, for we are not to suppose that all have been cast in a single mould. All the specimens indicate a low intellectual organization, little removed from that of the idiot.

On comparing the figure with a European skull, these anatomical traits will be apparent by contrast, particularly the increased development of the frontal and parietal regions, the outward

curving of the occiput, the horizontality of the line between the occipital ridge and the foramen magnum, and the convexity of the squamosal suture.

It is the preponderance of the brain-case over the facial portion of the head, that gives to man his superiority as compared with the lower animals; and we estimate the intellectual force and capacity for improvement in the several races of men by the same standard. The skull, in size and outline, has a general conformity to the enclosed brain; the bony walls take their shape from the nervous tissue, as the shell of the oyster is shaped to accommodate its living tenant. The brain is undoubtedly the seat of mental activity; and, without indorsing phrenology in all its details, we may affirm that a particular form of skull is indicative of particular traits of character. We place the seat of the intellectual faculties in the anterior lobe; of the propensities which link us to the brute, in the middle lobe; and of those which appertain to the social affections, in the posterior lobe. The predominance of any one of these divisions in a people would stamp them as either eminently intellectual, or eminently cruel, or eminently social.

The mound-builders, assuming these skulls to be typical, were doubtless neither eminent for great virtues nor great vices, but were a mild, inoffensive race, who would fall an easy prey to a crafty and cruel foe. Under the guidance of a superior mind, we can imagine that they would be content to toil, without weighing deliberately the nature or amount of the reward. Like the Chinese, they could probably imitate, but not invent; and, secure from the irruption of enemies, they would in time develop a rude civilization.

The Indian possesses a conformation of skull which clearly separates him from the pre-historic mound-builder, and such a conformation must give rise to different mental traits. His brain, as compared with the European, according to George Combe, differs widely in the proportions of the different parts. The anterior lobe is small, the middle lobe is large, and the central convolutions on the anterior lobe and upper surface are small. The brain-case is box-like, with the corners rounded off; the occiput extends up vertically; the frontal ridge is prominent; the cerebral vault is pyramidal; the interparietal diameter is great; the superciliary ridges and zygomatic arches sweep out beyond the general line of the skull; the orbits are quadrangular; the forehead is low; the cheek-bones high; and the jaws prognathous. His character,

since first known to the white man, has been signalized by treachery and cruelty. He repels all efforts to raise him from his degraded position; and whilst he has not the moral nature to adopt the virtues of civilization, his brutal instincts lead him to welcome its vices. He was never known voluntarily to engage in an enterprise requiring methodical labor; he dwells in temporary and movable habitations; he follows the game in their migrations; he imposes the drudgery of life upon his squaw; he takes no heed for the future. To suppose that such a race threw up the strong lines of circumvallation and the symmetrical mounds which crown so many of our river-terraces, is as preposterous, almost, as to suppose that they built the pyramids of Egypt.

Was there an Autochthonous Race having this form of Skull?

In the results of archæological explorations at other points on this hemisphere, we have evidence of the existence of nations whose skulls had many of the distinctive features which appertain to those of the mound-builder.

Dr. Lund, a distinguished Swedish naturalist, many years ago, in the bone caves of Minas Geraes, Brazil, found the remains of men associated with those of extinct quadrupeds under circumstances which led him to believe that the whole were contemporaneous. In his communication to the Geographical and Historical Society of Brazil, an abstract of which was forwarded to Dr. Morton by Lieutenant Strain, he says:—

> The question then arises, Who are these people? Of what race, and what their intellectual perfections? The answers to these questions are, happily, less difficult and doubtful. He examined various crania, in order to determine the place they ought to occupy in anthropology. The narrowness of the forehead, the prominence of the zygomatic bones, the maxillary and orbital conformation, all assign to these crania a place among the characteristics of the American race, and it is known that the race which approximates nearest this is the Mongolian; and the most distinctive and salient character by which we distinguish between them is the greater depression of the forehead in the former. In this point of organization, these ancient crania show not only the peculiarity of the American race, but this peculiarity, in many instances, is in excessive degree, *even to the entire disappearance of the forehead.*
>
> We know that the human figures found sculptured on the ancient monuments of Mexico, represent, for the greater part, a singular conformation of head, being without forehead, the crania retreating backward immediately

above the superciliary arch. This anomaly, which is generally ascribed to an artificial disfiguration of the head or taste of the artist, now admits of a more natural explanation, it being proved by these authentic documents that there really existed in this country a race exhibiting this anomalous conformation. The skeletons, which were of both sexes, were of the ordinary height, although two of them were above the common stature. These heads, according to the received opinion in craniology, could not have occupied a high position intellectually.*

Upon the altar-tablets and bas-reliefs of Copan and Uxmal, in Central America, as reproduced by Catherwood, we have this type of skull delineated by artists who had the skill to portray the features of their race. These artists would not select the most holy of places as the groundwork for their caricatures. This form, then, pertained to the most exalted personages.

Humboldt and Bonpland were the first to draw attention to this remarkable configuration of skull. The former, as far back as 1808, thus stated:—

This extraordinary flatness is found among nations to whom the means of producing artificial deformity are totally unknown; as is proved by the crania of Mexican Indians, Peruvians, and Atures, brought over by M. Bonpland and myself, of which several were deposited in the Museum of Natural History of Paris.†

Mr. Pentland supposed this conformation to be congenital, and states that this view was confirmed by Cuvier, Gall, and many celebrated anatomists. Tiedemann's expressions are: "A careful examination of these skulls has convinced me that their peculiar shape cannot be owing to artificial pressure. The great elongation of the face and the direction of the plane of the occipital bone are not to be reconciled with this opinion, and therefore we must conclude that the peculiarity of shape depends on a natural conformation." Knox says: "The form of the head I speak of is peculiar to the race; it may be exaggerated somewhat by such means (pressure), but cannot be so produced."

Sir Robert Schomburgk found, on some of the affluents of the Orinoco, a tribe known as the Frog Indians, whose heads were flattened by nature. A child was born while he was with them, which he saw an hour after its birth, that had all the character-

* Journal Academy of Natural Sciences, Philadelphia, 1844.

† Political Essays, vol. i. p. 159.

istics of the mother's tribe; "and the flatness of its head, as compared with the heads of other tribes, was remarkable." *

Rivero and Tschudi, whose researches in South America command confidence, believe that the artificial disfigurement of the skull, which prevailed among the Inca-Peruvians, owed its origin to the prior existence of an autochthonous race, having this peculiarity; and they further state that it is seen in the fœtus of Peruvian mummies.

Retzius, contrary to the opinion of Morton, has shown that the ancient Peruvians and the Huanchas of Tschudi were *Dolicocephali* (although he regards their skulls as much disfigured by artificial compression); while the Aztecs belonged to the *Brachycephali*. He has further shown that this practice of artificial deformation, instead of being confined to this continent, was in vogue among some of the Oriental nations, among the Swiss Lake-dwellers, and that it still exists in France. †

Upon the question whether this peculiarity, if the result in the first instance of artificial pressure and persisted in for generations, would become congenital, the following authorities may be cited. "In all changes which are produced in the bodies of animals by the action of external causes, the effect terminates in the individual; the offspring is not in the slightest degree modified by them." ‡

"Nothing," says Dr. Prichard, "seems to hold true more generally, than that all acquired conditions of body, whether produced by art or accident, end with the life of the individual."

Darwin would probably account for this peculiarity on the ground of Sexual Selection. §

These authorities would indicate that there was a conformity in the craniology of the earlier races on this hemisphere, embracing the primeval people of Brazil, the Huanchas of Peru, the Platform-builders of Mexico, and the Mound-builders of the Mississippi Valley.

The Peruvian skull, as compared with the Indian, is deficient in capacity, being, according to Morton, no greater than that of the

* Journal Royal Geographical Society, xv. pp. 53–54.

† Retzius, In relation to the Form of the Human Skull, *passim*.

‡ Lawrence, Lectures, &c., p. 436. For the compilation of many of these authorities, I am indebted to Mr. S. F. Haven, "Archæology of the United States" (Smithsonian Contributions).

§ Descent of Man, chap. viii.

Hottentot or New Hollander. In measuring 155 crania of the former, they gave but seventy-five cubic inches for the bulk of the brain, while the Teutonic crania gave ninety-two inches. The average between the Peruvian and Indian is nine inches in favor of the latter.*

How is it, then, it has been asked, that with this low mental power, these Peruvians should have been able to construct such stupendous works, and develop a very considerable civilization, while the Indian, with far greater volume of brain, exhibits such slight constructive power, and has resisted all attempts to elevate his condition? Mr. J. S. Phillips has attempted to answer this question: —

> The intellectual lobe of the brain of these people, if not borne down by such overpowering animal propensities and passions, would doubtless have been capable of much greater efforts than any with which we are acquainted, and have enabled these barbaric tribes to make some progress in civilization. . . . The intellectual and moral qualities of the Mexicans and Peruvians are left more free to act, not being so subordinate to the propensities and violent passions.†

Below, I give the contours of the most anomalous skulls referred to in this paper, reduced to a uniform scale (Fig. 16).

So great is the range of variation in the crania of the living tribes of men that it is unsafe to pronounce upon their average capacity except from an examination of a large collection. Thus far but few authentic mound-builders' skulls have been exhumed, and they indicate that that race must have ranked intellectually below the lowest types of Australia and New Caledonia.

Leaving out the Engis skull which shows a good degree of development, it may be said that the earliest types of man are inferior, as indicated by the Neanderthal skull, as well as by those recovered from the Danish and British tumuli, to say nothing of the strange human jaw found by Dupont in Belgium, which approaches those of the anthropomorphous apes, and another jaw of analogous traits found by the Marquis de Vibraye in France, both of which are supposed to be referable to the dawn of the human period. There is nothing to indicate modern degeneracy, whether applied to the intellectual or physical capacity of the Teutonic race. So far from it, there are strong grounds for believing that

* Morton's Crania Americana.

† Appendix to Morton's Physical Type of the American Indian.

our remote ancestors lived in brutal barbarism, with modes of thought and daily pursuits far different from those of the educated and much-planning man of to-day; and that, through a state of progression, long continued, often checked, but still acquiring strength to advance, a portion of the human family have been able to attain a high degree of civilization, — a civilization which implies intellectual culture and an ability to render the forces of nature subservient to human wants and conveniences.

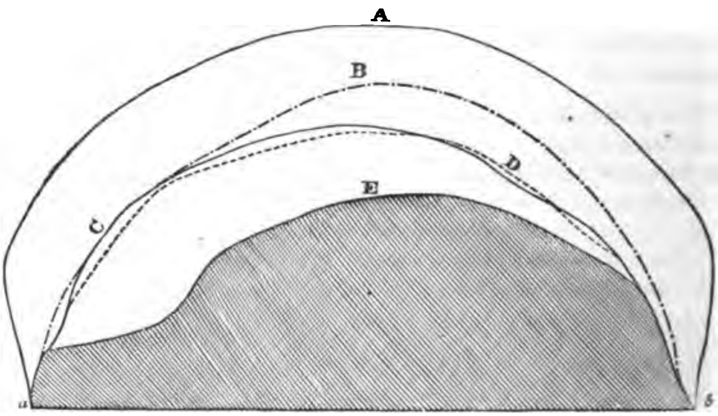

Fig. 16. — Comparative size of different skulls.

A Contour of European skull.
B „ that from Stimpson's Mound, No. 1.
C „ that of the Neanderthal skull.
D „ that from the Dunleith Mound, No. 9.
E „ the Chimpanzee skull.
a The glabella.
b The occipital crest.

That the investigator may comprehend the relative rank which the mound-builder occupied in what I may call the scale of humanity, I give the following table of measurements of the crania of the superior and inferior races of mankind, as they exist at this day; those from the United States being taken from "The Military and Anthropological Statistics of the War of the Rebellion," published by the Sanitary Commission, under the editorship of Dr. B. A. Gould, and those from foreign sources being reproduced from Huxley: —

TABLE OF MEASUREMENTS.

NOTE. — If the hair and scalp were removed, the circumference would be reduced from one to one and one-half inches.	Circumference around forehead and occiput.	Distance between condyloid processes.			Periphery from eyebrows to occipital crest.
		Over forehead and occiput.	Over top of the head.	Over occiput.	
White Soldiers	22.13	11.31	13.31	11.82	14.48
Iroquois	22.48	12.08	13.71	11.58	14.45
Mulattoes	22.00	12.34	14.11	12.24	13.55
Negroes	21.91	10.98	13.95	11.55	14.40

In the following table, while giving the measurements of English and Australian skulls, as well as of those known as the Engis and Neanderthal skulls belonging to a pre-historic race, I also append, for the purpose of comparison, the measurements of the true mound-builders' skulls described in this paper:—

TABLE OF MEASUREMENTS.

NATIONALITY.	A.	B.	C.	D.	E.	F.
English	21.	13.75	12.50	4.40	7.87	5.33
Australian (No. 1). .	20.50	13.	12.	4.75	7.50	5.40
„ (No. 2). .	22.	12.50	10.75	3.80	7.90	5.75
Engis, Belgium. . .	20.50	13.75	12.50	4.75	7.75	5.25
Neanderthal, Prussian Empire	23.	12.	10.	3.75	8.	5.75
Merom, Indiana (No. 4)	20.50	12.87	11.25	4.	7.25	5.50
„ „ (No. 5)	20.62	12.87	12.	3.87	7.37	5.37
„ „ (No. 6)	19.50	12.50	11.62	4.37	6.62	5.62
„ „ (No. 7)	21.	13.50	12.50	4.12	7.12	6.
Chicago, Illinois (No. 1)	20.25	12.50		3.80	7.60	5.75
Laporte, Indiana . .	18.50	10.50	10.30	3.80	6.50	5.

A. The horizontal circumference in the plane of a line joining the glabella with the occipital protuberance.
B. The longitudinal arc from the nasal depression along the middle line of the skull to the occipital tuberosity.
C. From the level of the glabello-occipital line on each side, across the middle of the sagittal suture to the same point on the opposite side.
D. The vertical height from the glabello-occipital line.
E. The extreme longitudinal measurement.
F. The extreme transverse measurement.

NOTE. — Professor Jeffreys Wyman, Curator of the Peabody Museum of American Archæology, in his "Fourth Annual Report" (1871), which has fallen under my notice since the text of this paper has been prepared, thus speaks of the collection of Mound-crania from Kentucky, made by the late S. S. Lyon, under the joint patronage of that Museum and the Smithsonian Institution: —

"A comparison of these crania with those of the other and later Indians shows that they have certain marked peculiarities, though these are better appreciated when the two kinds are placed side by side, than from any tables of measurement or verbal descriptions.

"The twenty-four crania measured show a mean capacity of 1,313 centimes, which is greater than that of the Peruvians, but less than that of the North American Indians generally (viz., 1,376 c. c., or 84 cubic inches). They differ, also, from those of the ordinary Indians in being lighter, less massive, and in having the rough surface on the muscular attachments less strongly marked. The top of the head shows a moderately angular or roof-shaped arrangement of the parietal bones, and the sides are vertical. In proportions, they present very considerable variations amongst themselves. Assuming the length of the skulls to be 1.000, the breadth ranges from 0.712 to 0.950 of the length. The average proportion is 0.857, which places them in the short-headed group. This result is influenced, but not to any great extent, by the fact that the crania have been somewhat distorted by a flattening of the occiput. In the majority, this flattening is very slight, and is indicated by a nearly plane surface just above the protuberance, and which would not materially diminish the length of the skull. The position of the foramen magnum is quite far back. We have shown elsewhere that in the North American Indians generally it is further back than in the Negro and other races with which they have been compared. In the Mound-crania the distance of the anterior edge of the foramen magnum from the occiput is only 0.372 the long diameter of the skull. This position can be only partially due to distortion, since in three skulls, in which the foramen was farthest back, the occiput was not in the least flattened."

The flattening of the tibiæ has been found to prevail among the skeletons belonging to the pre-historic nations of the Old World, presenting in this respect a resemblance to the corresponding bones of the ape. Dr. Wyman recognizes this peculiarity in a large series of bones obtained from the mounds of Kentucky, Tennessee, and Michigan, and from the shell-heaps of Florida. He, however, remarks that "this can hardly be considered a race character, since it is found in only about one-third of all the individuals observed." (Fourth Annual Report, pp. 21, 22.)

Dr. H. F. Harper recognized the same peculiarity in the skeletons recovered from the mounds of Merom, Indiana. He remarks: "I have six tibiæ in my possession which were taken from a mound, besides the fragments sent you, which were the most flattened of any. By measurement, all have a transverse diameter of from ten to fifty per cent less than the antero-posterior, while the extremities are enlarged transversely, as in our race. Two of the six are shorter and heavier than the others, and are curved anteriorly and full half an inch or more out of line. These two have also a transverse diameter almost equal to the antero-posterior one." — *Private Memoranda.*

TITLES

OF

COMMUNICATIONS.*

A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

1. A Discussion of the Forces of Expansion and Contraction. By J. D. Warner.

2. An Hypothetical Explanation of Expansion. By J. D. Warner.

3. A New Projection of the Sphere, Convenient in many Physical Investigations. By Thomas Basnett.

4. The Direction of Energy. By H. F. Walling.

5. Simple Apparatus for Students for Quantitative Demonstrations in the Physical Laboratory. By G. Hinrichs.

6. On a Compensating Clock Pendulum. By W. L. Coffinberry.

7. On the Law of Probability as Applied to the Determination of Mental Exertions. By G. Hinrichs.

8. The Force at any Point of the Surface of a Rotating Fluid Ellipsoid of Three Unequal Axes, under the Action of the Gravity of its own Particles and the Accompanying Centrifugal Force. By R. J. Adcock.

* The following papers were also read: of some, no copy has been received for publication; of others, it was voted that the title only should be printed. No notice, *even by title*, is taken of articles not approved.

9. Diagram of a New Cluster of Stars, with Remarks. By Thomas Basnett.

10. Description of the Printing Chronograph at the Dudley Observatory. By G. W. Hough.

11. Planetary Motion and Solar Heat. By Charles E. Phelps.

12. Solar and Lunar Photography. By Joseph Winlock.

13. The Temperature of the Sun. By H. F. Walling.

14. On Binary Stars. By Daniel Kirkwood.

15. On a Field-Stage for Clinical Microscopes. By R. H. Ward.

16. Outlines of a Plan to construct a Large Telescope for Special Observations. By Thomas Basnett.

17. Remarks on the Magnifying Powers of Objectives. By R. H. Ward.

18. On a New Object Cabinet. By R. H. Ward.

19. A Description of a New Binocular Stand. By A. H. Tuttle.

20. Refraction Tables modified and expanded from Bessel's Formulæ, to be used without Logarithms, Computed with the Scheutz Tabulating Engine. By G. W. Hough.

21. Description of the Polescope, an Optical Instrument. By C. G. Wheeler.

22. A Chemical Theory of Electricity. By H. F. Walling.

23. On the so-called Velocity of the Electric Current over Telegraph Wires. By G. W. Hough.

24. Demonstration of Magnetic Apparatus. By T. C. Hilgard.

25. The Conversion of the Sulphates of Potash and Soda into Carbonates in the Moist Way. By J. Lawrence Smith.

26. THE USE OF LEAD IN THE SULPHATE OF COPPER BATTERY. By G. W. HOUGH.

27. THE DISTRIBUTION OF THE RUBY AND SAPPHIRE IN THE UNITED STATES, WITH EXHIBITIONS OF SOME SPECIMENS FROM MONTANA. By J. LAWRENCE SMITH.

28. THE VALUE OF LABORATORY WORK IN CONNECTION WITH THE TEACHING OF CHEMISTRY, TOGETHER WITH A BRIEF SKETCH OF THE CHEMICAL LABORATORY OF THE IOWA STATE AGRICULTURAL COLLEGE. By A. E. FOOTE.

29. AN ACCOUNT OF AN IRON METEORITE THAT WAS SEEN TO FALL IN SOUTH AFRICA. By J. LAWRENCE SMITH.

30. ON THE PRODUCTION OF SPIEGELEISIN, EMBODYING A PAPER BY HUGH HARTMANN. By J. W. FOSTER.

31. ON THE DYNAMICAL CONDITION OF THE THREE STATES OF AGGREGATION. By G. HINRICHS.

32. ON THE ULTIMATE ANALYSIS OF COAL. By E. T. COX.

33. SIMPLE ARSENIC APPARATUS FOR THE CERTAIN DETECTION OF MINUTE TRACES OF ARSENIC IN TOXICOLOGICAL INVESTIGATIONS. By G. HINRICHS.

34. PYRITE ON THE LATERAL EDGES OF CALCITE SCALENOHEDRA. By G. HINRICHS.

35. THE USE OF AUTOMATIC INSTRUMENTS FOR REGISTERING METEOROLOGICAL PHENOMENA. By G. W. HOUGH.

36. A BRIEF STATEMENT OF EFFECTS OF THE THUNDER STORMS OF JULY AND AUGUST OF THE PRESENT YEAR IN THE VICINITY OF BOSTON. By W. W. WHEILDON.

37. THE RELATION OF THE UNITED STATES COAST SURVEY TO THE GEOLOGICAL AND TOPOGRAPHICAL SURVEY OF THE STATES. By BENJAMIN PIERCE.

38. CLIMATIC CHANGES IN THE SALT LAKE VALLEY. By P. A. CHADBOURNE.

39. HYPSOMETRICAL DATA OF SOME OF THE NORTH-WESTERN STATES. By ALEXANDER WINCHELL.

40. The Friction of the Progressive Motion of Water in the Tide Wave, being less than the Friction of the Return Under-Current upon the Bottom, the Tide Wave does not lengthen the Day. By J. D. Warner.

B. NATURAL HISTORY.

1. Coal, and some of its Special Uses. By E. B. Andrews.

2. Classification of the Rocks of Iowa. By C. A. White.

3. Characteristics of the Mineral Deposits in the Cottonwood Districts of Iowa. By P. A. Chadbourne.

4. Glacial Deposits of Northern Ohio. By John B. Perry.

5. Origin of Limestone in the Coal Measures. By E. B. Andrews.

6. Some Observations in Topographical Geology in North Carolina. By W. C. Kerr.

7. On the Geological Age of the Coal of Wyoming. By E. D. Cope.

8. A Fossil Horse from the Drift of Iowa — (Metacarpal Bone). By J. W. Foster.

9. Elephas Indianapolis: a New Species of Fossil Elephant. By J. W. Foster.

10. Peculiarities of Structure in the Wings of Certain Hymenoptera. By O. S. Wescott.

11. Tornaria, the Young Stage of Balanoglossus. By Alexander Agassiz.

12. On the Oviducts of Brachiopods. By E. S. Morse.

13. Organisms in Drinking Water. By H. W. Babcock.

14. On the so-called Sexual Characters of Copepoda. By A. H. Tuttle.

15. Media for the Preservation of Entomostraca. By O. S. Wescott.

16. Observations on Living Rhynchonella. By E. S. Morse.

17. On Zoölogical Barriers, with Special Reference to South America. By James Orton.

18. On the Gigantic Mammals of the Genus Loxolophodon. By E. D. Cope.

19. Circulation in Insects. By Robert King.

20. On the Eocene Genus Synoplotherium. By E. D. Cope.

21. On a New Genus in the Lepidopterous Family Tineidæ, with Remarks on the Fructification of Yucca. By C. V. Riley.

22. Respiration in Plants. By Robert King.

23. On some Ancient Carved Stones from New England. By F. W. Putnam.

24. Good Wine, a Social and National Good. By G. C. Swallow.

25. Doliolium and Appendicularia from Narragansett Bay. By Alexander Agassiz.

EXECUTIVE PROCEEDINGS

OF

THE DUBUQUE MEETING, 1872.

HISTORY OF THE MEETING.

The Twenty-first Meeting of the American Association for the Advancement of Science was held at Dubuque, Iowa, commencing on Wednesday, August 15, and continuing to Tuesday evening, August 21.

One hundred and sixty-four names are registered in the book by members who attended this meeting. One hundred and twelve new members were chosen, of whom ninety-two have already signified their acceptance by paying the entrance-fee and annual assessment, and, when practicable, signing the constitution. One hundred and one papers were presented, most of which were read, and some of them discussed at length.

The general sessions of the Association were held in the Congregational Church. Section B met in this Church, and Section A in the Universalist Church. The Standing Committee and Permanent Secretary found ample accommodation in the Façade Building.

At about ten o'clock, A.M., on Wednesday, the members were called to order by the President, Dr. J. Lawrence Smith, who made a few appropriate remarks, and then invited the Rev. E. K. Young to ask the Divine guidance and blessing upon the meeting. The Association proceeded next to complete the organization of the meeting, by choosing the additional members of the Standing Committee, agreeably to the provision in the constitution. Then the Association adjourned, to meet in sections; Section B remaining

in the place of general meeting, and Section A assembling in the Universalist Church. After each section had been organized by the election of Chairman, Secretary, and Sectional Committee, it proceeded at once to the reading of papers.

At eight o'clock in the evening there was a formal reception of the Association by the Local Committee. H. T. Woodman, Esq., Chairman of the Local Committee, called the meeting to order, and announced that Hon. W. B. Allison, United States Senator elect, would welcome their distinguished guests to the City of Dubuque. Senator Allison then made the following address:—

MR. PRESIDENT, GENTLEMEN AND LADIES, MEMBERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:—

The Committee having the arrangements in charge have assigned to me the pleasing duty of welcoming you to our city, and extending to you the hospitalities of its citizens.

Since the announcement of your coming was first made, all our people have looked forward to the occasion as an eventful one in our history.

We extend to you this cordial greeting and sincere welcome, not for yourselves alone, but because you are the distinguished representatives of the best thought and the highest culture of the age in which we live; because you are of that army of toilers who have done so much to advance the material interests of our country, and to accelerate its march among the civilized nations and peoples of the earth. It has been your mission, and the mission of such as you, to change old customs and habits; to unsettle old opinions, theories, and beliefs; to destroy ancient follies, prejudices, and superstitions; to inform and improve everywhere; to direct inquiry, study, and investigation into all things; to advance every nation and every people to a higher plane of thought and action.

Under our system of government no shackles or fetters are placed upon your investigations: the great truth is recognized that the State has no concern with the opinions of men. Here Science, with her bold, inquisitive spirit, has established her right to investigate all subjects after her own fashion and according to her own method; has enthroned herself in our schools of learning, colleges, and universities, and is working her way steadfastly and firmly

into our common-school system. And our own countrymen, thus guided, are entitled to their full share of the honors of discovery, invention, and improvement.

We cannot show you here, in our young North-West, old temples or ancient works of art, the accumulation of centuries of civilization; nor even the magnificence to be found in older portions of our own country. But we have an intelligent, economical, and industrious population, building and adorning as their means accumulate, and accumulating with an energy and rapidity unknown in older communities.

They all bid you welcome to our city and to the hospitality of their homes.

Though we are comparatively young as a State, Nature here as elsewhere is old; and, as you delight in its study, you will find many interesting subjects of inquiry and contemplation, whether it be among the crevices of our rocks, the rocks themselves, or among the fugitive boulders that have floated to us from distant regions, or among our extensive coal-fields, or over the broad expanse of the prairies that extend far away to the west of us, covered with indigenous plants and flowers, — each and all will be to you subjects of interest. Arrangements have been made for excursions and trips into the interior to enable you to conduct these observations and studies.

We look to you and your associates to encourage and aid us, in the future, in making our young State a great commonwealth for the happy abode of millions of Christian men and women, working as you work, though in varied channels, for the continued growth and advancement of our race.

You come among us strangers. We hope to treat you as friends, and that your stay may be pleasant and profitable to yourselves, as I am sure it will be to us. And I trust that when we part it will be with mutual pleasant recollections.

Professor Asa Gray, the retiring President of the Association, bowed to the honorable speaker when he had finished, and relinquished to his successor, Professor J. Lawrence Smith, the privilege of replying, which he did, as follows: —

It is with pleasure that I return to the citizens of Dubuque, through you, the thanks of the American Association for the Advancement of Science for the cordial invitation to hold our meeting

here this year, and for the still more cordial greeting that we have received since coming into your city. Yet it was nothing but what we expected; for while the march of empire is westward, hospitality and all its sister virtues tread with steady step in the front ranks of that march. In the vestibules of the houses of old Rome, it was common to inscribe upon the floor "Salve," and I behold in the countenances of all the people of Dubuque, man, woman, and child, the same word, "Welcome."

In a community where we have never been before, it may be well to say a word or two in relation to the objects and aims of this Association, which are not fully understood by the public. The object of this Association is to search for truth, and thereby to elevate and to improve mankind, which is the end of all truth, whether religious, moral, or scientific; and the members of this Association are active toilers in the pursuit of it, piling up truth upon truth in the erection of that great temple of science, whose author and finisher is God, and whose cap-stone will not be laid until the end of time. We are in one sense like those who toiled upon the temple of Solomon, some fashioning the stone, others shaping timber, yet others making the metals, but no one knowing the ultimate uses to which the several parts are to be applied, until the architect puts them in their respective places. Then the beauty and harmony of design become apparent to even the most untutored eye. As it took many different craftsmen to erect the temple of Solomon, so it requires many different scientists to perfect the various parts of their temple, each intent upon his particular work without any inquiry as to how or where it is to be placed; the astronomer, chemist, geologist, &c., working in separate spheres, but recognizing the mutual dependence of one on the other. This Association is looked upon by many who come to the meetings as intended to furnish, in some shape, popular lectures. So far from this being the case, the various subjects brought forward and discussed are of the most technical character, understood by only a few of the members of the Association. And it is too often asked in these cases of what use is all this or that? To such I can reply in the words of Coleridge, "What is the use of a new-born child?"

As we look for the use of the new-born child in its development into a full-grown, vigorous man or woman, so do we look at any new-born fact that has no immediate application. Out of the development of this fact may, possibly, spring some great and

important application that may revolutionize the whole face of society.

When I arrived in the city I took up one of your city newspapers, and read that workmen were putting up poles and wires along one of the alleys. What, I might have asked, was the use of them? Oh, you would have told me, it was that the proceedings of the Association might be printed the same day in New York City; or, it was in order, if need be, to send a despatch to Calcutta to ascertain how much hotter it is there to-day than in Dubuque. A similar answer I might give to those *cui bono* men; I could say to them, "Of what use was it that a hundred years ago an Italian placed the legs of a dead frog on some zinc plates?" and yet out of that insignificant scientific fact has grown a system of communication that has revolutionized the world, and saves millions of lives every year; for the railroads of the country are all operated by them. This shows to you and to every one that no man should scorn any truth, no matter how apparently small it may be.

Again, gentlemen, I thank you, and hand you over to the retiring President, who will enlighten and entertain you with, I have no doubt, a very *flowery* address.

At the close of Dr. Smith's remarks, Dr. Gray delivered his address (as retiring President), which is printed in full in this volume.

President Gray remarked, in conclusion, that the only duty on his part remaining undone was to ask the Association to welcome the President elect, Professor J. Lawrence Smith, of Louisville, to the chair.

President Smith, on assuming the chair, said: —

I am sensible of the honor conferred upon me by the Association, and particularly do I deem it an honor when your [to Professor Gray] mantle falls upon my shoulders. In 1871 a son of Massachusetts took this chair. In 1872 a son of South Carolina takes it. It is not the first time that a son of South Carolina and a son of Massachusetts have been shoulder to shoulder. God grant that it may not be the last!

During this meeting of the Association, the Standing Committee met regularly every morning at nine o'clock; the Association con-

vened at ten o'clock, and, after the transaction of general business, it adjourned to meet immediately in Sections. For most of the time two Sections (A and B) were found sufficient, but on one day Sub-section C (Microscopy) held a session in the Façade Building. On Thursday evening, August 16, Professor E. S. Morse gave a lecture before the members of the Association, skilfully illustrated on the blackboard; and on Saturday evening, August 18, Colonel C. G. Forshey read his paper on the "Physics of the Mississippi River." These general meetings, as well as those of the sections, were largely attended by the citizens of Dubuque, who took great interest in the meeting. The working members of the Association have always been reluctant to encroach upon the short time allotted to the annual meeting, by making excursions even of a partly scientific character, especially as many were of such a character as would only interest a portion of them. On this account expeditions were made, this year, to localities in the neighborhood, by those especially interested, without interrupting the sessions of the sections. Some took a trip, by invitation of Mr. Woodman, to the Indian mounds in the vicinity of Eagle Point. Some accepted the invitation of Mr. Graves, President of the Chicago, Clinton, and Dubuque Railroad, to make an excursion in the direction of Bellevue, and enjoy the opportunity afforded for seeing the river beach, the overhanging bluffs, and the geological structure of the country. Others, again, visited Griswold & Co.'s Mine, entered the Spar Cave, and saw the furnace of Brunskill and Coates in operation.

On Monday evening, August 20, the members of the Association, and the ladies who accompanied them, were handsomely entertained by the ladies of Dubuque, at the Lorimier House. The whole of Tuesday, August 21, was devoted to a general excursion to McGregor, arranged by President Graves of the River Railroad. Most of the members of the Association, with their ladies, and in company with many gentlemen and ladies of Dubuque, in all to the number of three hundred, joined in this pleasant trip. The company travelled by railroad as far as the Pictured Rocks, where they alighted to make an examination of these geological curiosities, of which they received explanations from Professor A. H. Winchell and Dr. A. C. White. The remainder of the journey to McGregor was made by the way of the river, in two steamers, united together by cables. The boats first went a mile down the river, so that a view might be obtained of the wonderful *Lotus*, which grows here in great luxuriance, some of the leaves being almost two feet in

diameter. The boats then steamed up the river, passing Prairie du Chien, and around the islands near McGregor, making a landing, at three o'clock, P.M., at McGregor. Here the members were received by Mayor Clark and escorted to Cambrian Hall, where a bountiful lunch was provided for them by the ladies of McGregor. Ex-Governor Merrill was introduced by the Mayor, who said a few hearty words of welcome, and then called upon Rev. W. M. Fawcett to ask the Divine blessing upon those who were going to partake of what had been liberally provided. After the pains of hunger had been assuaged, some informal speeches were made by Dr. J. Lawrence Smith, Colonel J. W. Foster, Professor Joseph Lovering, Professor E. S. Morse, Professor Asa Gray, Professor G. C. Swallow, and Colonel C. G. Forshey. The company returned all the way by railroad to Dubuque, where they arrived at six, P.M., exceedingly gratified by the great pleasures of the occasion.

The Association voted to hold its next meeting at Portland, Maine, beginning Wednesday, August 20, 1873. The officers elected for the next meeting are:—

Professor JOSEPH LOVERING, of Cambridge, Mass., *President;* Professor A. H. WORTHEN, of Springfield, Ill., *Vice-President;* C. A. WHITE, Esq., of Iowa City, *General Secretary;* W. S. VAUX, Esq., of Philadelphia, *Treasurer.* Professor JOSEPH LOVERING having resigned the office of Permanent Secretary, which he has held during fourteen sessions of the Association, F. W. PUTNAM, Esq., of Salem, was elected *Permanent Secretary* for two years, commencing with the next meeting.

RESOLUTIONS ADOPTED.

Whereas, It has come to our knowledge during this meeting of the Association, that the work of the geological survey of Iowa, so well and ably begun and conducted by Professor Hall and Dr. White, is suspended; and,

Whereas, It appears from what has been done and published that there still remain unfinished those minute and detailed examinations which are so necessary to render the work complete and most useful to the agricultural, mining, mechanical, and commercial interests of the State;

Resolved, That in the judgment of this Association the interests of the great State of Iowa demand the completion of the survey, under the direction of Dr. White, in a manner and style commensurate with the present advanced state of geological science, and the material progress of this great Commonwealth.

Resolved, That a committee of five be appointed by the chair to memorialize the Governor and Legislature of Iowa with the view of securing this result.

Whereas, A surplus from the so-called "Chinese Indemnity Fund" amounting now, as is believed, to about $450,000, remains in possession of the government of the United States, and it is the opinion of competent judges that this surplus belongs in law and equity to the United States; and,

Whereas, A Bill is now pending in Congress which proposes to appropriate this surplus for the education of Americans and Chinese in the languages, literatures, and sciences of the respective nations, to facilitate commercial, diplomatic, and scientific intercourse between the two peoples, and for the increase and diffusion of knowledge among men;

Resolved, That the American Association for the Advancement of Science heartily indorses the purpose of the aforesaid Bill to devote to the uses of education and science in China any portion of the so-called "Chinese Indemnity Fund" which may equitably remain in the possession of the government of the United States.

Resolved, That the Standing Committee be requested to inquire into the expediency of compiling a general index of the printed "Proceedings" of the Association, under the general direction of the Permanent Secretary, to be published for the use of the members of the Association.

Resolved, That the Association authorize the Permanent Secretary to print 250 copies annually of the Constitution, By-Laws, and List of Members, to be distributed at the opening of each meeting.

Resolved, That the Association regrets the absence of a signal station at Dubuque, a place that has recognized the importance of meteorological observations, and has kept records of this nature for twenty years; and that the Association respectfully requests the War Department to establish one here if practicable.

Resolved, That the Standing Committee accept the resignation of Professor Joseph Lovering as Permanent Secretary of this Association; and, in accepting that resignation, do direct his successor to enter upon the records of this Association the expression of our thanks for the courtesy, ability, and untiring industry with which he has discharged the duties of his office during a period of fourteen meetings.

VOTES OF THANKS.

Resolved, That the hearty thanks of this Association are hereby tendered to the citizens of Dubuque for the generous provision made for the present meeting, and for the unstinted hospitality with which they have welcomed us to their homes; and to the ladies of Dubuque for their courteous reception of the Association at the Lorimier House.

Resolved, That the American Association is most of all indebted to the Local Committee for the success of the Dubuque meeting. In their energetic and untiring labors and generous contributions we recognize a noble devotion to science, and a chivalric confidence in the ability and progress of the central region of the Republic. We tender them our hearty thanks in the name of American Science.

Resolved, That the thanks of the Association are pre-eminently due to the Trustees of the Congregational and Universalist Societies of Dubuque for their kindness in allowing us their churches for the purposes of this Association.

Resolved, That while acknowledging the courtesy and valuable aid of the members of the Iowa Institute of Arts and Sciences, we would also recognize the energy and ability shown in the preparation of their valuable collection, which is destined, we trust, in time, to rival the museums of the older and larger cities. In parting with the kindly and cultivated citizens of Dubuque, we hope our visit may prove to have stimulated new zeal in the members of the Institute in their scientific labors. And be it further resolved that a full set of the "Proceedings" of the Association be presented to the Iowa Institute of Arts and Sciences.

Resolved, That the thanks of the Association be given to the Directors of the Chicago, Dubuque, and Minnesota Railroad, and to its President, Mr. J. K. Graves, for their liberality in providing transportation for the members on the excursion of to-day. Also,

to Mr. Lawler, for the use of his steamboats in surveying the bluffs and circumnavigating the islands of the Mississippi; and to the ladies of McGregor for their bountiful entertainment, prepared by their hands and graced by their presence.

Resolved, That while we regret our inability to avail ourselves of the proffered hospitality of the citizens of Monticello, Iowa, of Independence, Iowa, and of the farmers of Delaware County, Iowa, who have invited us to participate in the festivities of their Harvest Home anniversary; and while we are compelled to deny ourselves the pleasure we would have doubtless enjoyed, we return the sincere thanks of the Association to our good friends of the above-named localities who have so kindly remembered us, and assure them that we fully appreciate the characteristic spirit of generosity that prompted their invitations.

Resolved, That the thanks of the Association are due to the Officers of the Chicago, Burlington, and Quincy Railroad, and of the Chicago, Clinton, and Dubuque Railroad, and of the Chicago, Dubuque, and Minnesota Railroad, for the courtesies extended to the members of this Association; and especially to the two last, in arranging special trains for their accommodation, without expense, to visit points of interest in the vicinity of Dubuque.

Resolved, That the Association gratefully acknowledges the generous offers of the Union Pacific and Central Pacific Railroad to convey the members over their roads to and from San Francisco at greatly reduced fares. Although the Association was prevented from holding this session on the shores of the Pacific, it desires none the less to record its sense of the liberality which rendered the acceptance of the invitation from California practicable.

Resolved, That the thanks of the American Association for the Advancement of Science be returned to the Dubuque Mannerchor for their cordial welcome.

Resolved, That the thanks of the Association be tendered to the Dubuque Rowing Club for their liberal expenditure of muscle in behalf of the Ichthyological and Entomological part of Section B.

Resolved, That the thanks of this Association are hereby tendered to the press for the wide and favorable notice given of the proceedings of this meeting; and that they acknowledge especial obligations to the reporters of the Dubuque Dailies, of the "New York Tribune," the "New York World," the "Chicago Tribune," "Chicago Evening Post," the Chicago "Inter-Ocean," and the "St. Louis Democrat," not only for the very full and accurate reports of the papers and discussions of the Association, but also for their uniformly courteous and friendly criticisms.

Resolved, That the thanks of the Association be presented to the retiring Officers, viz., the President and Vice-President, the Permanent Secretary and General Secretary, for the very able and successful manner in which they have performed the duties of their several offices.

REPORT OF THE PERMANENT SECRETARY.

THE following report comprises the business which has been done for the Association during the interval between the first day of the Indianapolis Meeting (August 16, 1871), and the first day of the Dubuque Meeting (August 15, 1872).

An unusually large number of copies of the Troy and Indianapolis volumes of "Proceedings" has been distributed to members. The list of Foreign Academies to which the "Proceedings" are sent is increased every year. The Indianapolis volume was ready for distribution on the first day of the present month, and has been sent by mail, *prepaid*, to all entitled to receive it. The delay in publication proceeds, partly from the necessity of sending proof-sheets over the whole country, some of which may not find the authors at home; and partly, from the neglect of authors to furnish a copy of their papers, at an early date, for publication. Many valuable papers are not sent at all, and some arrive too late even for the requirements of the slowly printed volume.

The financial condition of the Association is as follows: —

Between August 16, 1871, and August 15, 1872, the income of the Association was twenty-four hundred and eighty-three dollars and fifty cents ($2,483.50).

Of this amount sixty-four dollars and fifty cents ($64.50) accrued from the sale of the printed "Proceedings," and the remainder from the admission fees and the annual assessments.

The expenses of the Association, during the same interval, amounted to twenty-three hundred and forty-one dollars and sixty-four cents ($2,341.64), which may be apportioned thus: —

Cost of paper, printing, and binding for the volume of Indianapolis "Proceedings"	$1,527.06
Charges connected with the Troy Meeting	159.00
Salary of the Permanent Secretary (five hundred dollars)	500.00
For circulars, postage, stationery, express, &c.	155.58

The particular items may be found in the cash account of the Secretary, which is herewith submitted as a part of his report. The balance in the Treasury of the Association, August 16, 1871, is seventeen hundred and eighty-two dollars and forty-six cents ($1,782.46).

JOSEPH LOVERING,
Permanent Secretary.

DUBUQUE, August 15, 1872.

CASH ACCOUNT OF THE PERMANENT SECRETARY.

DR. AMERICAN ASSOCIATION *in account with* JOSEPH LOVERING. CR.

Dr.		Cr.	
Printing Circulars	$7.50	Balance from last Account	$1,640.60
Removing Stock of Books	7.00	From Assessments, and Sale of "Proceedings" (see from No. 251 to No. 784 inclusive of Cash Books)	2,483.50
Wood-cuts	25.00		
Electrotypes	3.36		
Box to Washington	5.55		
Express	18.39		
J. W. Harris, for Assistance at the Meeting	84.00		
Postage	99.29		
Plate	12.00		
Composition, Press-Work, &c., of Indianapolis "Proceedings"	1,420.33		
Binding Indianapolis "Proceedings"	66.37		
Stationery	11.52		
Discount	1.00		
Salary of Permanent Secretary	500.00		
Attending Indianapolis Meeting	75.00		
Telegram to San Francisco	5.33		
	$2,341.64		
Balance to next Account	1,782.46		
	$4,124.10		$4,124.10

STOCK ACCOUNT OF THE PERMANENT SECRETARY.

Volumes Distributed or Sold, since the Report in Vol. XX.

VOLUMES.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.
Distributed to Members														1	2	2	5	10	62	542
Harvard College																				1
Boston Public Library																				1
American Academy																				1
Boston Natural History Society																				1
Connecticut Academy of Science																				1
Yale College																				1
Brown University																				1
Boston Athenæum																				1
Philadelphia Academy Nat. Sci.															1	1	1	1	1	1
Smithsonian Institution																				1
Peabody Academy of Science																				1
Amherst College																				1
Columbia College (N.Y.)																				1
Peabody Library (Balt.)																				1
Providence Athenæum																			1	
Foreign Societies *										1	1	1	2		1	2		2	1	79
Sold (this year and last)	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	5	7	5
Total	1	1	1	1	1	1	1	1	1	2	2	2	3	3	6	7	8	18	72	640
Balance, August, 1872	86	93	226	212	414	271	510	833	933	878	808	928	986	1108	564	487	416	379	420	
Received from Binders, &c.	8																			933
Balance, May, 1873	88	92	225	211	413	270	509	832	932	871	806	926	983	1105	558	480	408	361	348	293

* See pages 276, 277.

List of European Institutions to which Copies of Volume XX. of the Proceedings of the American Association were distributed by the Permanent Secretary in 1872.

Stockholm, —Kongliga Svenska Vetenskaps Akademien.
Copenhagen, — Kongel. danske Vidensk. Selskab.
Moscow, — Société Impériale des Naturalistes.
St. Petersburg, — Académie Impériale des Sciences.
„ „ Kais. Russ. Mineralogische Gesellschaft.
„ „ Observatoire Physique Centrale de Russie.
„ „ Jardin Impérial de Botanique.
Pulkowa, — Observatoire Impériale.
Amsterdam, — Académie Royale des Sciences.
„ Genootschap Natura Artis Magistra.
„ Zoölogical Garden.
Haarlem, — Hollandsche Maatschappij der Wettenschappen.*
„ La Société Hollandaise des Sciences.
Leyden, — Musée d'Histoire Naturelle.
„ The University Library.†
Utrecht, — Institut Royal Météorologique des Pays-Bas.
Altenburg, — Naturforschende Gesellschaft.
Berlin, — K. P. Akademie der Wissenschaften.
„ Gesellschaft für Erdkunde.
Bonn, — Naturhist. Verein der Preussisch. Rheinlandes, &c.
Brünn, — Naturforschenden Vereins.
Dresden, — K. L. C. Deutsche Akademie der Naturforscher.*
Franckfurt, — Senckenbergische Naturforschende Gesellschaft.
Freiburg, — Königlich-Sächsische Bergakademie.
Göttingen, — Königl. Gesellschaft der Wissenschaften.
Hamburg, — Naturwissenschaftlicher Verein.
Hannover, — Die Naturhistorische Gesellschaft.
Königsberg, — Königliche-Physikalish Okonomischen Gesellschaft.
Leipsic, — Königlich-Sächsische Gesellschaft der Wissenschaften.
Munich, — K. B. Akademie der Wissenschaften.
Posen, — Naturwissenschaftlicher Verein. ‡
Prag, — K. Böhm. Gesellschaft der Wissenschaften.
Stuttgart, — Verein für Vaterländische Naturkunde.
Vienna, — K. Akademie der Wissenschaften.
„ K. K. Geographischen Gesellschaft.
„ Geologischen Reichsanstalt.
„ Osterreichische Gesellschaft für Meteorologie.

* Also Vol. ii.
† Also Vols. xiii., xiv., xv., and xvi.
‡ Also Vols. x., xi., xii., xiii., xiv., and xvi.

Vienna, — K. K. Zoologisch-Botanische Gesellschaft.
„ Verein zur Verbreitung Naturwissensch. Kentnisse.
Basel, — Naturforschende Gesellschaft.
Bern, — Allgemeine Schweizerische Gesellschaft.
„ Naturforschende Gesellschaft.
Genève, — Société de Physique et d'Histoire Naturelle.
Lausanne, — Société Vaudoise des Sciences Naturelles.
Neuchâtel, — Société des Sciences Naturelles.
Zurich, — Naturforschende Gesellschaft.
Bruxelles, — Académie Royale des Sciences, &c.
Liége, — Société Royale des Sciences.
Bordeaux, — Société Linnéenne.
Cherbourg, — Société Académique.
Dijon, — Académie des Sciences, &c.
Lille, — Société Nationale des Sciences, de l'Agric., et des Arts.
Montpellier, — Académie des Sciences et Lettres.
Paris, — Institut de France.
„ Société Philomatique.
„ Société Météorologique de France.
Strassburg, — Kaiserl. Universitats- und Landes- Bibliothek.*
Genoa, — Societa di Letturi e Conversazioni Scientifiche.
Milan, — Reale Istituto Lombardo di Scienze e Lettere.
Rome, — Osservatorio Astronomico del Collegio Romano.
Turin, — Accademia Reale delle Scienzie.
„ Pubblicazioni del Circolo Geographico.
Madrid, — Real Academia de Ciencias.
Cambridge — Cambridge Philosophical Society.
Dublin, — Royal Irish Academy.
Edinburgh, — Royal Society.
Liverpool, — The Literary and Philosophical Society.
London, — Board of Admiralty.
„ East India Company.
„ Museum of Practical Geology.
„ Royal Society.
„ Royal Astronomical Society.
„ Royal Geographical Society.
„ Royal Institution of Great Britain.
Manchester, — Literary and Philosophical Society.
„ Natural Hist. Soc. of Northumberland, Durham, &c.
Newcastle-upon-Tyne, — The Tyneside Naturalist's Field-Club.
Oxford, — Radcliffe Observatory.
Batavia, — Société des Arts et des Sciences.

* Also Vols. xvii. and xix.

REPORTS.

THE following is the report of the Committee of the American Association for the Advancement of Science in regard to holding the meeting of 1872 at San Francisco.

At the session of the Association, held at Indianapolis in 1871, the following resolutions were passed: —

1st, That the next meeting be held at San Francisco, on the first Monday in August, 1872, if, in the opinion of the Standing Committee, satisfactory arrangements could be made.

2d, That if the arrangements could not be made satisfactory to the Committee, that the meeting should be held in Dubuque, Iowa, at the usual time; viz., on the third Wednesday in August.

Immediately on the adjournment of the Association, steps were taken by the individual members of the Committee to see what could be done with the directors of the railroads for conveying the members of the Association to San Francisco. While this was doing, we received a letter from San Francisco, dated October 6th, as follows: —

"We have not received any official notices of the acceptance of our invitation, but acting on your note to me, unofficially noting the fact, I have been directed by the trustees to open correspondence with railroad officials, East, to get the best rates we can for guests. I am going for twenty free passes both ways for your distribution to the foreign guests you may invite, and such of your members as you may designate. I may not succeed in getting that many, but, if we get half of them, we intend to raise a fund to pay for the other half.

"We would be glad if you invited, say six or ten from Europe, including Tyndall, Huxley, and Hooker. I intend to open negotiations with steamship lines from Europe on the subject of half fares for them, and will advise you of the result."

Other letters of a similar nature were received, and encouraged your Committee in their labors, who finally succeeded in making favorable terms with the railroads; viz., for the round trip for members of the Association from Omaha to San Francisco and back, $64, and half rates on the roads east of Omaha. Some of the details concerning the manner of paying the fare were not satisfactory; but, as they in no wise altered the amount, this could have been

accommodated. We then commenced making arrangements with the Ocean Steamers, and inviting foreign guests as requested. After proceeding thus far, we sent several communications to San Francisco, but, by reason of misdirected letters, or snow blockade, we did not receive answers to these communications. About this time a telegram was received from the President of the California Academy of Science and the Director of the Geological Survey to say that, in their opinion, the meeting in San Francisco should be deferred to another year. Consequently your Committee accepted the cordial invitation which continued to be extended to us from Dubuque by both letters and telegrams. In conclusion, we would say that, if much has been lost in not going to San Francisco, more has been gained in coming to Dubuque, for nothing could excel the overflowing kindness of the people of this small but enterprising city of the great State of Iowa.

ASA GRAY.
JOSEPH LOVERING.
J. LAWRENCE SMITH.
(For the Committee.)

The Committee formerly appointed to report on a Revision of the Constitution, if such revision was deemed necessary by them, after due consideration reported as follows:—

Your Committee to report if any Revision of the Constitution of the Association is required, beg to report that, after a careful study of the Constitution and Resolutions of the Association, they find that no change is necessary, as the points to which the vote of the last meeting called their attention are fully provided for. But they also beg to report that they find several violations of the Constitution of common occurrence, and that they think a strict adherence to it to be of vital importance to the Association.

F. W. PUTNAM.
G. C. SWALLOW.
(For the Committee.)

APPENDIX.

SCIENTIFIC EXCURSION ACROSS THE STATE OF IOWA. By WILLIAM W. WHEILDON.

AT the conclusion of the sessions of the Association, on Monday, August 26th, and after the return of the members from the social and festive visit to the city of McGregor, on the Upper Mississippi River, on Tuesday, — which combined river and railroad travel with extraordinary scientific interest, — a more extensive excursion was arranged by the Illinois Central Railroad Company, from Dubuque to Sioux City and back again. Such members of the Association as desired to join in the excursion were kindly furnished with the necessary tickets for the purpose, and the "Section" — as we felt that we might call it — left Dubuque on Wednesday morning, the 28th. The section comprised about forty in number, and included many prominent and active members of the Association, and several ladies, who had been attending its meeting. There were five or six State geologists, a number of botanists, and others, all interested in the study of natural history and the pursuits of science.

The excursion proposed was directly across the State of Iowa, from the Mississippi River on the east, to the Big Sioux and Missouri Rivers on the west, a distance of three hundred and twenty-seven miles; and many inducements were presented, calculated to make the excursion both interesting and profitable to the party, and promotive in some degree of the cause of science. The meeting of the Association, just concluded, is the first which it has held west of the Mississippi River, — a region embracing by far the largest portion of our country; and the rich valley lying between the two great continental rivers, before they become united into one stream, hardly less than that larger region lying beyond the Mis-

souri, was almost wholly unknown, so far as personal observation goes, to the members of the Association. The recent history of this region — and none other is open to us, unless it be to some extent geologically — is to be found scattered through many volumes of more or less value, and in the public documents of the government, which are generally accessible to those who desire to be particularly acquainted with it. The city in which the Association held its sessions is less than a hundred years old, having been settled by the French Canadians in 1786, — then barely entitled to be called an outpost of civilization; and now it numbers a population of more than twenty thousand persons, possessing, as indicative of the taste and intelligence of the people, a museum of natural history and kindred sciences, and a public library. Of course, these simple statements carry with them the evidence of a general advancement in wealth and refinement, — all of which, without needless display of any kind, combined to render this meeting of the Association of the most gratifying character. The attentions bestowed upon the Association and the kindness shown to its members, as well as the large attendance upon its sessions, we feel justified in saying, are regarded as manifesting a high appreciation of its purposes and a respect for its members, alike complimentary to them and not less honorable to the city.

In this excursion the Section was favored with the company of Dr. C. A. White, of the Iowa State University, and State Geologist;* and in order to follow to some extent the rules of the Association, as applied to its working sections, Dr. White was elected chairman; and to him was intrusted not only the general direction of the party, but, we may say, its edification also. Familiar as he is with the geography and the geology of the State, its rivers, lakes, mines, quarries, and prairies, it appeared to be a pleasure to him to give any information in regard to these which might suggest itself to him or be desired by the party; so that, in point of fact, Dr. White *lectured* to his attentive and interested audience during the entire journey of two days across the State, and, as for that matter, nearly all the way back, until we parted with him at Fort Dodge.

* Dr. White's elaborate work on the Geology of the State has been published in two large and elegant volumes, illustrated with maps, diagrams, and drawings; and is a very valuable addition to the works of its character and class.

With the usual occurrences and incidents of travel over this new and peculiar country, so destitute of those features which in New England characterize the landscape, — hills and vales, and forests and rocks, — our stopping-place for the night was at the city of Fort Dodge, on the Des Moines River, 192 miles from Dubuque. We were at this place about a thousand feet above the level of the sea, and 444 feet above the Mississippi River at Keokuk.

Fort Dodge and its neighborhood compose an extremely interesting region, both historically and scientifically. After the transfer of the vast country west of the Mississippi River, included in the Louisiana purchase in 1803, to the United States, one of the military posts for the protection of the surveying parties was established at this point on the Des Moines River, in 1849. The barracks used by the troops, when the region was in possession of the Indians, are still standing within the streets of the present city; and one of the veterans of that period who served under General Mason (Major Williams), and was at one time acting military governor over an almost boundless territory, still resides in the city.

The Section were received by the citizens of Fort Dodge, in a most generous and hospitable manner, into their hearts and homes. In the evening there was a reception at the residence of Mrs. Swain, a member of the Association, at which an opportunity of meeting with some of the citizens of the place was afforded and enjoyed.

The next morning, Thursday, 29th, was devoted to a scientific exploration of the neighborhood, — mine and quarry, forest and river. Carriages were provided by the citizens for all the members of the Section, and some of them accompanied the party in their explorations. Among the places visited were the limestone quarries and kilns, the coal mines, the river, and Lizard Creek; and, chiefest of all, the famous gypsum quarries, known hereabouts as the birthplace of that audacious imposition, the "Cardiff Giant." From among the hills and groves, which undulate and beautify the river banks, we passed over a few miles of elevated prairie ground, and entered the canyon, for it is almost that, in which the gypsum beds are visible in the bluffs upon either side of it. Through this gorge, or narrow valley, runs the Soldier Creek, in its summer glory, babbling or foaming or spreading itself thinly over a smooth sandy surface; and we had to cross it (of course fording it) no less than six times in a hundred rods. It has been running through this

valley, impetuous in its littleness though boisterous at other seasons, for ages, and may undoubtedly be said to have "worked its passage" through the soft gypsum deposits. The stream itself was lovely; and, while its banks were green and beautiful, its companionship was pleasant and inspiring. Stopping in full view, though far above us, of the position whence the Cardiff giant was blocked out, Dr. White interested the Section in a description of the gypsum field, its extent, and the quality and the uses of the article. It has been used to some extent in Fort Dodge as a building material, and arrangements are in progress to furnish a supply of plaster of Paris from it for the purposes of agriculture and the arts. It is not probable that it will be much used for statuary hereafter. The gypsum beds of the Des Moines River and its tributaries are said to be the largest and most valuable in the country, and the only beds of any economical value in this or the adjoining States. Its peculiarity is its remarkable purity and freedom from grit, so that it is hewn with axes and hatchets, sawed with a common wood-saw, and blasting-holes, when necessary, are made with a common carpenter's auger; yet as a building material, though it may be cut and defaced with a penknife, it retains its beauty of coloring and its durability nearly as well as marble. It may be sawed into slabs or blocks of any size; and, when calcined and ground as plaster of Paris, it is applicable to the highest purposes of art, as well as to ordinary agriculture.

Returning from the gypsum quarries, we crossed the Des Moines River, and from the bluffs of its western shore obtained some fine views of the city, the river, and the surrounding country. Our visit proved to be highly satisfactory, socially and scientifically, not only to the members of the Section, but not less so to the citizens of Fort Dodge, and will be pleasantly remembered by all.

At 3.40 P.M., we left our friends at Fort Dodge, and in a car kindly provided for our party, proceeded on our way to Sioux City. Our route for the whole distance of one hundred and thirty-five miles was over the open and apparently boundless prairie, unbroken by an elevation and almost unrelieved by tree or shrub, save the rank weeds of the prairie. The weather was warm and pleasant, and particularly favorable for the most extended views over the prairie, which, especially towards the north, seemed like the open ocean; and visions of the broad swell of the sea scarcely required an effort of the imagination. For a distance of more than fifty miles, the track of the railroad was as straight as an arrow; and, looking

back from the rear of the train, a very slight grade, hardly more than the curvature of the earth, we might imagine, could be observed. The prairie was not entirely new to the party, excepting in its apparent boundlessness; but it still seemed strange to those in whose minds "the idea of a wilderness was indissolubly connected with that of a forest." Beyond the Ohio River, "the traveller, as he wanders successively over Indiana, Illinois, Missouri, and the vast wilderness lying beyond, is astonished at the immensity of the great plain, the verdure, the beauty, of its wide-spread meadows." In our case nothing could be more interesting than the broad prairie views, opening from all the windows of the car, during a ride of more than a hundred miles, which may scarcely be said to be diversified with a few trees, and a few houses, a river or two, a lake or two, and for most of the time the visible horizon bounding the landscape. Many times as we have seen them, lived upon them, studied them, we never look upon these boundless prairies without wonder at their vast extent, their marvellous fertility, their beautiful green covering, brilliant with flowers and instinct with life in so many forms.

Notwithstanding the apparently level country over which we had travelled for two days, we had risen to an altitude of more than fifteen hundred feet above the sea, and had as imperceptibly dropped down again to two-thirds of that elevation. The summit level in our journey was passed near Storm Lake, — a spot made memorable with blood in Indian history, and whose peculiarity is that its waters flow from opposite ends into different streams.

After a very agreeable and interesting journey during the afternoon, our Section reached its destination and western limit, at 10.15 P.M., unexpectedly, as we were surprised to learn, to the citizens. We had passed since leaving Dubuque, in the three hundred and twenty-seven miles over this comparatively new country, more than forty stations, each of which of course represents the town, and frequently constitutes all there is of a settlement. It seems that we were expected at four o'clock in the afternoon, at which hour a public reception had been arranged, carriages provided for the use of the party, and there would also have been a gathering in the evening; all of which, with whatever benefits might have occurred, were lost to us and to them by our delay. We found ample and elegant accommodations at the Hubbard House, — a large and princely hotel, — and received the visits of some of the prominent citizens during the evening.

Our chairman, Dr. White, in consultation with the citizens, made the necessary arrangements for the movements of the party for the following day.

Friday, August 30. — This morning after breakfast, the Section assembled in the drawing-rooms prepared for the excursions of the day. Carriages were placed at their disposal, and Dr. White organized the companies and arranged the excursions. Parties sallied out in different directions around the city, and the whole neighborhood was visited.. The Big Sioux River was crossed into the territory of Dakota, and the Missouri River, at a point below, into Nebraska; and short rides were taken in each, chiefly of interest to the botanists of the party. The celebrated bluff named after the first settler of the city, Brughier, was visited, and from this point was seen the junction of the Sioux River with the Missouri. The geologists had ample and enjoyable opportunities of visiting the cretaceous formations of this region, and numerous specimens were obtained by them. Quite a number of specimens of small fishes were also obtained from the river by our ichthyologists, and not a few moths and bugs. Floyd's River was crossed, and the bluff three miles below the city, where Floyd was buried at the time of Lewis and Clarke's expedition, was seen, but not visited. Some of the highest eminences in the State are to be found a few miles north of this city, on the Sioux River, 1500 feet above the level of the sea; and from these the views are picturesque and beautiful, including innumerable bluffs in all directions, groves of trees, the courses of the two rivers, and the great level valley lying between them.

The region around Sioux City was found to be very interesting, historically, geologically, and geographically; and much pleasure and profound scientific interest were enjoyed by the party, especially that portion of it which had the privilege of listening to the instructive remarks and explanations of Dr. White. It is hardly too much to say that the bluffs, rivers, forests, quarries, and even the swamps in the neighborhood of the city, were visited by the geologists, botanists, ichthyologists, and bug-hunters of the party; and wherever there was fine scenery to be found, upon the bluffs and along the rivers, there some of our æsthetic members were sure to be seen.

In the evening, after the excursions of the day, the Section reassembled in the drawing-rooms of the Hubbard House, compared notes of the day's exploits, and received the calls of many of the

citizens with their ladies. At an early hour, the company was called to order by the chairman, Dr. White, and committees appointed to prepare resolutions, expressive of the sense of the company, for the invitation extended to them by the railroad company and the attentions received from the citizens of Sioux City. Subsequently, Prof. Perry, from the first named committee, reported the following: —

Whereas, The Illinois Central Railroad Company has kindly favored such members of the American Association for the Advancement of Science as wished to make an excursion westward with free tickets from Dubuque to Sioux City, and back again; therefore,

Resolved, That we tender our most hearty thanks to the said railroad company, and in particular to the General Superintendent and to G. N. Candee, Esq., for their kind and untiring efforts to promote our comfort and pleasure during the excursion.

Mr. W. W. Wheildon, from the second committee on the reception and entertainment at Sioux City, reported the following resolutions, and all were unanimously adopted by the meeting and published in the local papers: —

Resolved, That the thanks of the Section, individually and collectively, be presented to the citizens of Sioux City for the attention and kindness bestowed on the occasion of our visit to this city and its interesting vicinity; and, further,

Resolved, That, recognizing their generous conduct as an evidence of interest in the cause of science on the part of the citizens of Sioux City, it is especially grateful to us, and will be regarded as an encouragement in future efforts for the advancement of science in this and all sections of the country.

After completing the business, the remainder of the evening was passed in very agreeable social intercourse with the citizens and ladies of the place, all of whom expressed their gratification at the visit of so large and respectable a body of scientists, and that the Association had honored the State by holding its first meeting west of the Mississippi within its limits.

The Return.

Saturday, August 31. — Having accomplished, as far as seemed practicable, the objects of the visit to Sioux City, this morning the members of the Section took the cars on their return. Passing again over the beautiful prairie, they reached Fort Dodge at noon, and were welcomed by their friends and invited to a dinner provided by the ladies of the city. The repast was served at the Fort Dodge House, and a number of ladies and gentlemen belonging to the city were present. At the conclusion of the dinner a vote of thanks for the kindness and attentions received was adopted; and much mutual good feeling was expressed at parting.

Visit to Springvale.

A number of our party, having accepted the invitation of Rev. S. H. Taft, President of the Board of Trustees of Humboldt College, at Springvale, tendered in behalf of the citizens, carriages were now in readiness to convey them to that place. Humboldt College is the latest educational institution of its class in the State, as Springvale is also one of its youngest municipalities. The town lies about sixteen miles north of Fort Dodge, and nearly at the point of junction of the east and west branches of the Des Moines River. The ride across the intervening country in the afternoon, quite in contrast with our extensive railroad journeyings, was a perfect pleasure.

We were received at Springvale with warm hearts and every expression of welcome, in the homes of the people; and in the evening there was a public reception at "Russell Hall," with the somewhat remarkable addition, as we thought, of a musical band. We thought perhaps the influence of "the Jubilee" had been felt even in these remote settlements. The exercises of the evening consisted of an address of welcome by Rev. Mr. Taft and remarks by Dr. White, Prof. Perry, Mr. Putnam, and Mr. Wheildon. The hall was filled to its utmost capacity, the people were very much interested, and the band furnished excellent music for the occasion. Later in the evening the band tendered a serenade to their visitors, and nothing was omitted to render the occasion pleasant and agreeable.

By arrangement of the two religious societies in the town, Prof.

Perry, on the following day and evening, delivered his two discourses on the Mosaic Creation and the Noachian Flood, in Russell Hall, to very crowded assemblies. They were particularly interesting and instructive, and gave great satisfaction. One of the clergymen announced his intention of preaching upon the subjects presented to the consideration of the people by the scientists on the next Sabbath.

On Monday, the scientists visited Humboldt College and other points of interest in the neighborhood; and in the evening the people assembled again to hear a lecture by Mr. Putnam, of Salem, on Fishes, and this gentleman presented his subject in a popular and interesting manner, illustrating the discourse with living specimens taken from the river in the vicinity.

On Tuesday, the party visited the oolite quarries and lime kilns, the point of land in Dakota City where the two branches of the river form a junction, and the admirable grounds belonging to the college. In the evening a lecture was delivered by Mr. Wheildon, on the Origin of the Races of Men, supporting the Bible account of the creation of man, controverting the idea of numerous creations, and expressing some views adverse to the Darwinian speculations. As on the previous evenings, the hall was crowded, many of the auditors coming considerable distances. At the conclusion of his discourse, Mr. Wheildon read a vote of the scientists expressing their thanks for the kindness and hospitality received; and the meeting passed a vote of thanks to the lecturer.

Here, it may be said, the public proceedings of our party closed. Many of the members had already left Springvale, and on Wednesday morning, September 4th, the remainder returned to Fort Dodge and took the cars for Dubuque; and there the excursion ended, each day having been passed happily and pleasantly. We had crossed and re-crossed the State, had visited many localities of historical and geological interest, had seen the beauty of the scenery and the richness of the soil, and measured, as far as the eye could reach, the almost boundless and beautiful prairies. This State, and perhaps all the States east of the Rocky Mountains, which are drained by the Missouri and Mississippi Rivers and their tributaries, are of similar geological character, composed for the most part of stratified rocks and drift. The rocks are altogether of marine origin, and are filled with remains of shells, corals, &c., as the coal fields are with vegetable remains. Minerals of various kinds, especially galena in the neighborhood of Dubuque, are found

in different parts of the State, and more or less in all the prairie States, but of course not as in the mountainous regions farther west. Although the rocks must have been deposited in horizontal layers, they are rarely found anywhere in this condition, so that not only the coal deposits, but nearly all other formations, crop out at the surface or are exposed in the river valleys. The advantages afforded by these conditions are especially favorable to geological observation and promotive of the progress of the science, as the relative position of these formations and the peculiar fossil remains which characterize them, accurately determined, are essential to the claims of geology as a science. American geology is already recognized abroad; and the labors of American geologists, in their ample and open fields, have contributed, and are now contributing largely to the advancement of the science.

The excursion of the Section, formed impromptu and almost without previous acquaintance among its members, and the attentions received at Fort Dodge, Sioux City, and Springvale, various and generous and inspiriting as these were, will be long remembered and cherished as among the pleasantest experiences of their lives. The whole excursion was enjoyed, not merely in its scientific pursuits, satisfactory as these were, but quite as much in its social activities and intercourse. These grew upon the party, both ladies and gentlemen, daily, and made the termination of our journeyings an undesired consummation. Of the same character, to some extent, were the friendships formed in the cities visited, where the kindnesses received seemed to teach us not only that —

"One touch of nature makes the whole world kin,"

but that we were of one country and one people.

But to these words of pleasure, recreation, and friendship, — so fully realized by all the members of the party, — the word of sadness must be added. We felt that the social enjoyments of our party must terminate, that many of us might not meet again; but we did not dream, when we separated, that one who had taken so active a part in the doings of the Association and of the Section during the excursion, as Prof. J. E. PERRY, — whom we all hoped to meet again, — would be removed from his sphere of labor and usefulness, and called up higher, even before all our party had reached their homes. Although he did not appear to be as strong in health as we could have wished, he shrunk from no effort; and we fear that the readiness with which he complied with the

wishes of others may have tasked his energies of mind and body too severely.

Prof. Perry had interested all our members in the learned and elaborate discourses delivered by him at Dubuque and repeated at Springvale, and we had enjoyed his conversation and companionship during the whole excursion. His quiet and gentlemanly bearing had attracted the observation and secured the respect of all the party, and we may truly say that none more sincerely than they mourn his early and sudden death.

In concluding this narrative of the longest and, in some respects, most practical excursion yet made by the members of our Association, we may be permitted to express the opinion that, whether it shall ever be repeated in any other direction or not, much good in the cause of science and scientific observation cannot fail to result from this, in the new and comparatively unexplored region visited. The people everywhere manifested the most lively and gratifying interest in the subjects of scientific inquiry, as the whole community appeared to do at Dubuque, and left no means unemployed to assist the members of the Section in the pursuit of their peculiar studies. Not only was a spirit of hospitality and friendliness invoked in our aid, but, as in the city where our meeting had been held, a desire was manifested by many to continue the investigations and observations initiated by their visitors, and follow in the paths of study in some small degree opened to their enlightened apprehension. "The pursuits of science," says Dr. Dick, "are fitted to yield a positive gratification to every human mind. It presents to view processes, combinations, metamorphoses, motions, and objects of various description calculated to arrest the attention and to astonish the mind far more than all the romances and tales of wonder that were ever invented by the human imagination. In order to make science advance with accelerated steps, and to multiply sources of mental enjoyment, we have only to set the machinery of the human mind in motion, and to direct its movements to those objects which are congenial to its native dignity and its high distinction."

In the true spirit of our Association, — the advancement of science, — we entered upon this excursion; and those who have enjoyed its pleasures are encouraged in the belief that it has not failed to leave pleasant remembrances in its paths, and perchance sown some seed that may hereafter give evidence of the hopes that inspired it.

ERRATA.

On page 180, line 16, for *ports* read *pools*.

" 152, " 2, for *N. Winchell* read *N. H. Winchell.*

" 168, " 27, for 96 read 106.

" 168, " 38, for 433 read 443.

" 168, " 39, for 393 read 403.

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